

F I F T H
R E P O R T

OF THE
SELECT COMMITTEE

ON THE

R O A D S

FROM LONDON TO HOLYHEAD;

AND

Into the Regulations for Conveying His Majesty's Mail
between London and Dublin,

&c. &c.

STEAM BOATS;

&c.

*Ordered, by The House of Commons, to be Printed,
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FIFTH REPORT.

THE SELECT COMMITTEE appointed to inquire into the state of the Roads from *London to Holyhead*, and from *Chester to Holyhead*; into the regulations for conveying His Majesty's Mail between *London and Dublin*, and between the Northern Parts of *England and Dublin*, and between *Dublin* and the interior of *Ireland*; and into the state of the Mail Coach Roads in *Ireland*; and to report their Observations thereon, together with the MINUTES of the EVIDENCE taken before them, from time to time, to the House;—HAVE agreed to the following REPORT.

YOUR Committee, since they presented to the House their Second Report, have prosecuted the inquiry, then only just begun, into the important subject of Steam Boats.

The first instance of applying Steam to vessels, is that which occurred in 1736, when Mr. Hull obtained letters patent for the construction of a Steam Boat for towing Vessels in and out of port. The application of paddle wheels, now so generally adopted, appears to have been originally suggested by this patent. Mr. Hull proposed to employ the atmospheric engine of Newcomen, which by means of a crank, communicating with the working beam, imparted a rotary action to the wheels and paddles which were placed at the bow of the vessel. Next in succession were the experiments of the Duke of Bridgewater, to use Steam Boats for towing Barges on Canals; and then came those of Mr. Miller, of Dalswinton in the county of Dumfries, in a double vessel with the wheel in the middle. But after Mr. Hull, the Marquis de Jouffroy unquestionably holds the most distinguished rank in the list of practical engineers, who have added to the value of the invention: In 1781, he constructed a Steam Boat at Lyons of 140 feet in length; and with this, he made several successful experiments on the River Saône. In 1795, Lord Stanhope constructed a boat to be moved by Steam. In 1801 Mr. Symington tried a boat that was propelled by Steam on the Forth and Clyde navigation. Still no practical uses resulted from any of these attempts. It was not till the year 1807, when the Americans began to use Steam Boats on their rivers, that their safety and utility was first proved. But the whole merit of constructing these Boats is due to natives of Great Britain; Mr. Henry Bell, of Glasgow, gave the first model of them to Mr. Fulton, and went over to America, to assist him in establishing them; and Mr. Fulton got the engines he used in his first Steam Boat on the Hudson river from Messrs. Boulton and Watt. Steam navigation seems to have made great progress from this time in America. It appears from the Report of the Select Committee of the Session of 1817, on this subject, that there were then seventeen large Steam Boats in constant employment on the American rivers, besides ferry boats; a list of Steam Boats has been published by Mr. Robinson, that shows that on the Mississippi alone, the tonnage of those in work at present, amounts to 7,259 tons, and of those building to 5,995 tons. There are now, in all, about 300 Steam Boats in use in America.

Mr. Bell continued to turn his talents to the improving of Steam apparatus, and its application in various manufactures about Glasgow; and in 1811, constructed the Comet Steam Boat, of twenty-five tons, with

See App. p. 2. of
Partington on the
Steam Engine.

B. p. 57.

See Mr. Watt's
Letter, p. 210.

See evidence of
Mr. Seth Hunt.

See Partington,
p. 67.

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an engine of four horse power, to navigate the Clyde between Glasgow and the Helensburgh Baths, established by him on an extensive scale. The success of this experiment led to the constructing of several Steam Boats, by other persons, of larger dimensions and with greater steaming power; these having superseded Mr. Bell's small Boat in the Clyde, it was enlarged, and established as a regular Packet between Glasgow and the western end of the Caledonian Canal at Fort William, by way of the Crinan Canal in Argyshire. Mr. Bell about the same time constructed the Stirling Castle Steam Boat, and employed her on the river Forth, between Leith and Stirling; he afterwards took her to Inverness, where she has been for two years plying between that town and Fort Augustus, going seven miles by the Caledonian Canal, and twenty three miles along Loch Ness. Many other Boats were successfully established about this time on the Forth and Clyde, and several on the rivers Tay, Thames, Mersey and Humber, and between Southampton and the Isle of Wight; but it was not till the year 1818, that a Steam Boat was made use of to perform regular voyages at sea. In this year the *Rob Roy*, of ninety tons, built by Mr. Denny of Dumbarton, and with an engine of thirty-horse power, made by Mr. Napier of Glasgow, plied regularly between Greenock and Belfast, and proved the practicability of extending the use of the Steam Engine to Sea Navigation. In the year 1819, the *Talbot*, of one hundred and fifty tons, built by Messrs. Wood, with two thirty-horse engines made by Mr. Napier, plied daily between Holyhead and Dublin, throughout the whole summer and autumn, and successfully encountered many severe gales. In the year 1820, the *Ivanhoe*, of one hundred and seventy tons, built by Mr. J. Scott, with two thirty-horse engines made by Mr. Napier, was established on the same station; and in 1821, the Postmasters General introduced Steam Boats at Holyhead and Dover for the conveyance of the Mails. During these three last years, the *Belfast*, *Robert Bruce*, *Waterloo*, *Eclipse*, *Superb*, *Majestic*, and *Cambria* were constructed, of large tonnage, and with engines of great power, for conveying passengers between Greenock and Belfast and Liverpool; between Liverpool and Dublin; and between Liverpool and Baginbun in Flintshire. All these vessels, except the *Cambria* and *Belfast*, were constructed in the Clyde. In the year 1821, the *City of Edinburgh* and *Mountaineer* were established to go between London and Leith; and, in the present year, there have already been fitted for sea the *St. Patrick* and *St. George*, at Liverpool; the *James Watt*, for the Leith and London station; the *Swift*, to go between Brighton and Dieppe; the *Sovereign* and *Union*, between Dover and Calais; and the *Lord Melville*, to go regularly between London Bridge and Calais; twelve more are in hand, and will be completed this summer. Ferry Boats propelled by Steam, sufficiently commodious to carry carriages, horses and cattle, have been established with great public utility on the Tay between Dundee and Fifeshire; at the *Queen's Ferry*, in Scotland; on the Severn, the Mersey and the Humber, and at other ferries.

See App. p. 198,
for the tonnage and
power of all these
vessels, and for
the names of the
builders and engine
makers.

See App. No. 1.

In the Appendix there is a list which has been made by Mr. Field, of all the Steam Boats which have been built in the United Kingdom, showing their tonnage* and the power of their engines; the names of the builders and of the engine makers; the date of their being launched, and also the station where they ply; from this list it appears, that in the space of a very few years the public have been accommodated, in all directions, with this safe, rapid and economical mode of conveyance.

* The tonnage of Steam vessels in this Report and in the Table in the Appendix, No. 1, is stated according to the statutory method of calculating it in other vessels.—The way of calculating the tonnage of Steam Boats is specially regulated by 59 Geo. 3. c. 5.

The experience of what Steam Boats have performed, is fully sufficient to place beyond all doubt their safety even in the most tempestuous weather. The Rob Roy plied two winters between Greenock and Belfast, and last winter between Dover and Calais; the Eclipse plied the whole of last winter between Glasgow and Belfast, and the Cambria between Liverpool and Bagilt; a Steam Boat has plied regularly, through all seasons, between New York, the Havannah and New Orleans; all the other Steam Boats which have been used at sea have been exposed to numerous severe gales. But the trial which the Holyhead Steam Boats went through during the last tempestuous winter, from the nature of the service requiring them to go to sea at a fixed hour every day, proves that Steam Boats, when properly constructed, are able to go to sea when Sailing Vessels could not, and that in some respects they possess, in very bad weather, advantages over Sailing Vessels. The following extracts from the evidence of Captain Rogers is quite conclusive as to the power and safety of Steam Boats at sea.

See Mr. Napier's
evid., p. 213.

"Q. Have you had full trial of the Steam Packets, with respect to gales of wind?—A. Yes, in every way. I crossed in the Meteor, on the 5th of February, in the heaviest sea I have seen during eight years I have been on the station.—Q. Have the Steam Packets sailed regularly during the whole winter?—A. Except a very few days; I have seen them go several times when Sailing Packets could not.—Q. Have you found that the Steam Packets built under the inspection of the Navy Board are as safe as any vessel you ever navigated?—A. Certainly.—Q. Is there any danger, in your opinion, to be apprehended from them as Steam Vessels?—A. No.—Q. Are you of opinion, that in the event of the engine failing, with the assistance of sails and the anchor you may keep a Packet in perfect safety?—A. There is no doubt of it; by putting two cables together, which she has on board, she would ride out any gale in the Channel as easy as a glove.—Q. Are the Committee to understand your opinion to be, that in any weather, however severe, the Steam Boats will stand that weather as well as any Sail Boat?—A. Yes, in any wind; the more wind the better for the Steam Boats; that is where they show their superiority.—Q. In the heaviest gale that could blow, you would rather be in a Steam Packet than a Sailing Packet?—A. Yes; that is, in a vessel of our construction.—Q. Have you found, in blowing weather, that the vessel works at all, either inside or out?—A. No, not at all; I do not see it in the least, not a single thing, she is as solid as a wall.—Q. Was the last winter a worse winter than usual?—A. I have heard it said that it has been the worst winter for fifty years; Lloyd's have paid more this winter than ever they did.—Q. Can you carry one boat on each quarter?—A. We can carry two, but all that is lumber; we never think of being drowned or burnt now." In another place Captain Rogers says, "I never read a novel before I was on board a Steam Packet, and I go down now frequently and read for an hour or two."

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The following extracts from the answers of the other Holyhead Captains, corroborate the evidence of Captain Rogers. Captain Goddard says, "These vessels by their performances through the past winter, have exceeded the most sanguine expectations; and certainly have made passages across the Channel, when the Sailing Packets would have found extreme difficulty to have accomplished them; and in so short a period of time as places their performance beyond the necessity of comparison to establish their great superiority." Captain Skinner says, "I am of opinion, a Steam Packet of about one hundred and eighty tons burthen, form similar to that of the Meteor, with a little finer entrance and strength of building, with masts and sails the same, would be the best; a vessel of

that description would be able to make a voyage, when it was fit weather for any other vessel to put to sea." Captain Davies says, "the two vessels on this station have answered wonderfully well."

The testimony of the Holyhead commanders is not only extremely important, in consequence of the experience they have had of the performance of the Steam Packets during the last winter, but also because it is to be recollected, that even after the *Talbot* and *Ivanhoe* had been on the station, it was their opinion that no vessel could perform the winter service with safety but Sailing Cutters, such as the old Holyhead Packets. This opinion it was natural they should entertain, knowing so well as they did, the heavy seas and desperate gales which frequently prevail for weeks together in the Irish Channel. But the trial of last winter having now brought them to acknowledge a change of opinion, this circumstance does every thing that by possibility could be wanting to establish, upon the best authority, the safety and superiority of Steam Boats for this service.

Notwithstanding the great number of Steam Boats which have been constantly in use, in different parts of the kingdom, during the last ten years, very few accidents have occurred, and these few were chiefly owing to the novelty of the experiment: so many precautions are now taken that there is no reason to apprehend the recurrence of any serious accidents. The general use of low pressure boilers made of wrought iron or copper has removed the possibility of accidents from their bursting. If one of these boilers gives way, the materials do not fly, but are rent asunder. This part of the subject was very fully investigated by the Select Committee on Steam Navigation in 1817; and the evidence given before that Committee contains every thing that is necessary to remove all apprehensions of danger from the bursting of low pressure boilers. In respect to the furnaces, they are so constructed that there is no danger from fire, because there is water all round them. Mr. James Brownsays, "I hardly think it possible that fire can take place, because the furnaces are completely surrounded with five inches of water round every part." The coals are kept in iron cases so as to prevent all communication with the fires; and if, in addition to these precautions, vessels are supplied with extinguishing fire engines, there is no danger of accidents from fire. It has been suggested, that Steam Vessels are not provided with a sufficient number of boats, and that an Act of Parliament should be passed to require every vessel to carry a certain number, according to her tonnage: but Your Committee, after the fullest consideration, are strongly of opinion that the policy of avoiding to do any thing that could by possibility check the spirit of improvement which now is so prevalent, and which promises such great advantages to the public, is that which ought to be followed. It is to be remembered, that the expense of fitting out Steam Vessels is very heavy, and that proper experiments of new inventions cannot be made but with the risk of incurring considerable loss; and as nothing would check the zeal of those who are disposed to make such experiments so certainly as the meddling of officers exercising the powers of a regulating Act of Parliament, nothing could be more baneful than the interference of the Legislature with this new branch of science. The Ballast Office of Dublin brought a bill before the House of Commons last year, for the purpose of appointing inspectors over the Liverpool and Dublin Packets; but the Chief Secretary of Ireland, Mr. Grant, very judiciously put a stop to its progress. Individual security in Steam Boats will always be sufficiently provided for, by the interest of the proprietors constantly contributing to lead them to do all those things which will best obtain the custom of the public. Competition in this case,

case, as in all others, will more effectually establish those precautions which are right to be taken, than the best devised regulations of an Act of Parliament. But at the same time that Your Committee decline to recommend any Legislative control, they are decidedly of opinion that the owners of Steam Vessels who omit to provide a sufficient number of boats, to secure the safety of their passengers, in case of any sudden accident, are guilty of great neglect, and not deserving of the countenance and support of the public. Besides this precaution, in respect to Boats, there ought to be on board every Steam Boat, for the perusal of the passengers, a certificate of some experienced engineer, to testify the strength of the boilers; the sufficiency of the valves; the safety of the furnaces, and the general good condition of the vessel and machinery.

The speed and regularity with which Steam Boats perform their voyages, is the next point worthy of being brought under the notice of the House.

The average length of the voyages of the Holyhead Packets, from the 1st of June 1821 to the 1st of June 1822, has been about seven hours and a half; the average of the Sailing Packets was fifteen hours. Captain Percy, who commands the *Hero* London and Margate Packet, says, "We generally make the passage in seven hours and a half, the distance being eighty-four miles." Mr. James Brown says, "the *Edinburgh Castle* has gone from London to Leith in fifty-eight hours, a distance of four hundred and fifty miles; but that the *James Watt* is a faster vessel, her speed being ten miles an hour through still water, independent of wind and tide." Mr. Traill states, that the *Majestic* has performed the voyage from Greenock to Liverpool, a distance of two hundred and forty miles in twenty-two hours; and that the *Saint Patrick* came from Dublin to Liverpool, one hundred and thirty miles, in thirteen hours and a half, against a stiff breeze from the east. The *Lord Melville* goes from London Bridge to Calais in eleven or twelve hours. This great speed with which the voyages are made by Steam Boats, adds considerably to their superiority over other vessels in point of safety; for in the same degree that the time occupied in performing a voyage is diminished so is the risk of danger also to which passengers are exposed.

It is now evident that the failure of all the early attempts to apply Steam to sea boats, was owing to their being built too square; to their want of strength, and to the want of a sufficient quantity of steaming power. According as boats have been built with a form planned on better sailing principles, with greater strength of timber, and with engines of increased power, the progress of their success has exactly corresponded with these improvements.

On referring to the list of Steam Boats in the Appendix, the *Talbot* and *Ivanhoe* on the Holyhead station, and the *Belfast*, *Eclipse*, *Superb*, and *Majestic* on the Greenock and Liverpool passage, will be found to be the first strong and powerful Boats which were built, and they were the first that completely succeeded. The strength and power of the Holyhead Packets are clearly the cause of their success; and the still greater power which has been given to each of the new boats the *St. Patrick* and *St. George*, lately built at Liverpool, namely, of two fifty-five-horse engines, promises to make them superior to any of their predecessors.

Your Committee having thus briefly given a general description of the rise and progress of Steam Navigation, will now proceed to make such observations, as the information they have obtained seems to justify, upon the more scientific part of the subject; and in doing this, they will divide it under four heads;—1st, The Form of the Vessel;—2d, Her Strength;—3d, The Machinery;—4th, Sails.

See App. No. a.

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Page 149, 150.

I. FORM OF VESSEL.

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Captain Rogers says, "In building a Steam Boat she ought to have a fine entrance, and her bow to clear off, not to shove any water before her; she should have a good line of bearing, and her transom pretty square, and not too high: the transom being square and low, and fine under, so as to give her a right line of bearing, will stop her pitching and rolling, and make her easy on the sea, and add to her speed." Captain Townley,

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who has been commanding Steam Boats, since 1819, between Dublin and Liverpool, says, "As to form, a Steam Vessel should have an extreme fine entrance below, rise well forward, and flare off, so as to let her fall easy into the sea, and throw it off when steaming head to wind; she should have but little rise of floor, so as to be pretty flat under the engines, and run off as clean as possible abaft: I approve of giving them a good deal of rake forward." Captain J. Hamilton, of the Arrow Post Office

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Dover Packet, recommends for wet harbours "a vessel with a rising floor about three inches hollow, to prevent her rolling; fair and easy curved water-lines; the stem to rake well, which makes her easy, going head to sea; the stern post to stand square to the keel, and to draw from seven feet nine inches to eight feet water." Mr. John Scott, ship builder at

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Greenock, says, "I have continued to make the fore body of my vessels very fine, with a good entry, which I have always found made the vessel sail faster, and easier impelled." Messrs. Maudslay and Field say, "The

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form of a Steam Vessel under water should be that of the fastest schooner, bold at the bows, the whole vessel rising but little out of the water; the

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spongings, or projecting work on the sides, added to the proper body of the vessel, and rising from the water-line at an angle nowhere exceeding

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forty degrees from the perpendicular of the side; the bulwarks, wheel cases, and all the exterior of the vessel, smooth and free from projections

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that would hold the wind." Messrs. J. and C. Wood, say, "The vessel should be formed with a fine entrance and run; sharp raking bow, both

below and above; a broad transom not too high placed; a good rise in the floor, limited by the draught of water and the occasion of taking the ground."

II. STRENGTH OF THE VESSEL.

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The regularity, speed and safety with which the Holyhead Steam Boats crossed the Irish Channel, throughout the whole of last winter, are the best evidence of the vast importance of great strength in the construction of this description of Vessels. Captain Rogers says, that he would rather be in a Steam Boat, in the heaviest gale that could blow, than in a Sailing Packet, if constructed like the Holyhead Steam Boats; and it is evident, from his whole testimony, that the great confidence he places in them is on account of their prodigious strength. He says, "their strength is owing to their being filled up solid to the floor head; to the timbers being put together and diagonally fastened on Sir Robert Seppings's plan; to their being caulked inside and out, having no tree nails, but bolted, and copper fastened; the bolts being driven on a ring clinched at both ends."

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Sir Robert Seppings, in his answers to the printed queries of the Committee, respecting the proper strength of a Steam Boat, says, "In point of strength, I consider that the principle introduced into the Sovereign and Meteor (Holyhead Packets), should be generally adopted in all Steam Vessels; and in fact in all other vessels, but particularly in those of the Packet class; as it gives safety in the event of the loss of the keel; and also a proportion of the plank of the bottom; either of which would be the destruction of a vessel constructed on the common principle." Sir Robert Seppings having delivered, with his answers to the printed queries,

a description

a description of his mode of building ships, accompanied with drawings to explain it. Your Committee have inserted them in the Appendix to this Report, in order to give as much publicity as possible to his valuable invention. Messrs. Maudslay and Field say, "The straining of a vessel at sea has frequently broken some parts of the machinery, but in a vessel well adapted for the open sea, her great strength should be a security against accident from this cause; the vessel should be exceedingly strong."

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Mr. J. Cook, of Glasgow, recommends that a Steam Vessel of one hundred and eighty tons should be built with a scantling for a Sailing Vessel of twice that tonnage. Mr. Roger Fisher says, "There has been, in my opinion, a great improvement made in the strength of Steam Vessels built here (Liverpool) lately; that is, by carrying the frame timbers up so as to form the projection of the sides, and then regularly planked up solid as any other part of the vessel, by which means they are much safer."

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Mr. Brunel, when asked whether he would recommend a Steam Boat to be built much stronger than usual for Sailing Vessels? gave the Committee to understand, that great weight would be injurious, by lessening the buoyancy of the vessel; but Captain Rogers's evidence corroborates the opinions of the other witnesses, and seems to show that this inconvenience does not follow:—"Q. Have you found those two vessels (the Holyhead Steam Boats) equally buoyant with any other you have sailed in?—

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A. Yes.—Q. Has the great weight of their timbers, and other materials, diminished their speed?—A. No; I think it rather gives them speed against a sea.—Q. Then the inconvenience anticipated from the mode of constructing these vessels has not taken place?—A. No; it has not."

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Mr. George Henry Freeling says, "I have attempted to gain some information about every Steam Vessel which has been built; and I am convinced these vessels (the Holyhead Packets) will do what no other vessels can do, they will go to sea in weather when nothing else can; I attribute that not only to the machinery, but to the great weight of the hull; a lighter vessel in a heavy sea would be checked; but these vessels have from their weight a momentum so great that it carries them on when a lighter vessel would be checked; the weight acts as a fly-wheel." "I have the authority of Mr. Lang of the Navy Board for stating, that with the exception of the Discovery ships, there are no vessels so strong."

Pages 174, 175.

III.—MACHINERY.

The Steam Engine, employed on board ships, is as yet a much less perfect machine than when it is used on land; the height of the cylinder is nearly one half less; the power is thereby cramped by short strokes, which are incalculably bad. In this way there is a great loss of power, as the *vis inertiae* is to be overcome on every stroke; more frequent alternations are necessary of the beam, the piston and the valves, which occasion more wear, and more friction than where the cylinders are made longer. There is also a considerable loss of power in converting the alternate motion of the piston into the rotary motion of the paddles.

The Engines, as now used at sea, want some contrivance to enable them to bear with the irregularity of the pressure on them; sometimes there is a vast excess, sometimes a deficiency, and sometimes a total absence of the resisting medium. "These irregularities throw the ungoverned and almost irresistible power of the Steam Engine into those convulsive starts that meet no other controlling check but the arm of the crank, from which it recoils with increased energy to the opposite side, occasioning thereby those destructive shocks, those alternate strains and wrenchings, which a frequent recurrence must render fatal to the cranks and to the shafts,

Mr. Russell's evidence, pp. 175, 176.

besides other parts of the Machinery." To remedy these defects by such combinations of Machinery as may enable the Engine to adapt and accommodate itself spontaneously to all the exigencies incident to its peculiar service, is one of the chief objects which should attract the attention of Engineers.

The great size of the Boilers, as now made, is very disadvantageous. They occupy a very inconvenient portion of the space within a vessel.

The method of fixing the Paddles is a very defective part of the Machinery: the oblique action of them in entering and departing from the water, produces that tremulous jarring which serves to loosen the seams and the bolting of the knees and beams of the vessel; it also occasions a very great loss of the steaming power.

In respect to the degree of strength proper to be given to the Machinery, almost all the Engineers, who have been examined, concur in the opinion that it ought to be very considerable. Messrs. Wood say, "all the connecting Machinery should be twice the strength for ordinary work on shore." Mr. Donkin says, that every part of the engine should be made at least of three times the strength, which, by estimation, would be required for any force to which it might be exposed. "Accidents," he observes, "are most likely to happen at a time when the suspension of the power of the engine would be most fatal."

Wrought iron is strongly recommended to be used in place of cast iron; and though some of the witnesses have expressed doubts of the practicability of making large shafts of wrought iron, Mr. Donkin does not hesitate to say, that "they can always be got quite perfect, if a sufficient price is given for them."

As so much of the safety of the vessel depends upon the workmanship of the materials, they should be proved before they are used, by a proper proving engine for trying their strength, as well by a force acting in a twisting direction, as by a strain in the direction of their length.

When Mr. James Brown was asked by the Committee, "Is an engine liable to that extraordinary pressure upon it, under particular circumstances, that it is better to have some part of it that would give way?" replied, "I should think so." Mr. G. H. Freeling says, "there must be some part of the engine left to give way in case of any emergency, which is better than destroying the cylinder." But Mr. Timothy Bramah, Mr. Donkin and Mr. Field, say, that the engine should be made so strong, that it may be brought to rest without the fracture of any of its parts, in case it met with a resistance that would require its ultimate power. They mention instances that have come under their own personal observation, of engines having, in this way, stopped with no other effect than that of the steam forcing open the safety valve and going off.

It may be collected from the evidence, that the greater part of the breakages which have occurred of different parts of the Machinery in Steam Boats, has been owing to the negligence of the engine keepers; Starting the engine without clearing off the water which is formed on the top of the piston, from condensed steam, is one cause of fractures; other accidents have arisen from suffering the bearings upon which the shafts work, and the links connecting the piston with the beam, to get loose; and in some cases from making them so tight, that the bearings heat; and also from not attending carefully to the steam valve when the vessel is exposed to a heavy sea. Mr. Watt says, "with the experience now obtained, we make no doubt but that we shall be able to construct Machinery less liable to accident; but much must always depend upon the vigilance

vigilance and experience of the men who work the engines." Mr. James Brown being asked what were the causes of accidents to the Machinery, replied, "they depended more on the engine keepers than any thing else."

Mr. Donkin says, "I have reason to believe that some of the Steam Boat Companies have suffered severely from a want of regular professional inspection;" and being asked, "Do you conceive that the injury to engines from neglect is greater than the injury arising from the actual working of them?" replied, "Yes, I do;" and being further asked, "Has that been a constant defect in the management of Steam Boats up to this period?" replied, "Yes, I conceive so."

All the evidence is so decidedly in favour of making boilers of copper, that it is necessary only generally to refer to it. Messrs. Fenton and Murray, of Leeds, say, "The boiler ought to be what we call a combined boiler, viz. three distinct boilers put together to form one boiler, with the fire passing three times through each, and so constructed as to be taken up and down a hatchway without pulling up or destroying the decks."

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Mr. Donkin and Mr. T. Bramah are of opinion that all boilers are now made too large, and that the same quantity of steaming power might be obtained with a smaller body of water, if the surface of the boiler exposed to the fire was sufficiently large.

All the witnesses agree in opinion as to the necessity of keeping the machinery as low as possible in the vessel: Mr. Watt says, "this will diminish the top weight, make the vessel more steady at sea, improve the action of the machinery, and add to the safety of the vessel." Messrs. Maudslay and Field say, "The best arrangement of the machinery, and in which engineers are most agreed, is to place the boiler or boilers a few feet abaft the centre of buoyancy of the vessel; the two engines on each side, a few feet forward of this point; and the coals on the centre of buoyancy: this arrangement brings the fuel, which is constantly variable, on a point that will not affect the trim of the vessel; it also brings the wheelshaft, which is at the foremost end of the engine, to its best position as regards the length of the vessel, viz. at about one-third from the head: the weight of the boiler, engine and coal, is thus spread pretty equally over the space allotted for them, and partial and intense weight on any one part is thus avoided."

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Several of the witnesses having mentioned the injurious effects of sea water upon the boilers, Your Committee examined Mr. Michael Faraday, who acts as chemical assistant to Mr. Brande at the Royal Institution, concerning the chemical properties of sea water. Mr. Faraday's evidence explains the temperature and degree of saturation of the water in the boilers at which various salts are deposited, and by what process the metals, of which the boilers are made, are injured. It appears that the greatest care is requisite on the part of the engine keepers to prevent the water in the boilers from being so much saturated as to occasion the deposition of the salts. When this takes place, these salts corrode the metal, and destroy a portion of it, and form crusts over the internal surface of the boilers, which having bad conducting powers as regards heat, diminish the quantity of the steam, and cause the fire to burn the boilers and the flues.

Mr. Faraday explains, that the injury done to iron boilers by the deposition of salts, is much greater than the injury which is done to copper boilers; an additional and a very strong reason for using the latter.

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Messrs. Mundsley and Field state, that the fire-places and boilers are frequently burned and injured from the incrustations made by deposited salts in the boilers, through neglect to change the water and clean the boilers; and Mr. Donkin says he has known great inconvenience from the same cause. In one instance, going to Margate, one out of three boilers in the vessel produced very little steam, in consequence of the incrustations on the bottom, a circumstance that was discovered by its requiring very little water to be introduced into it. Mr. Donkin further says, that he knows only of two methods by which the deposition of salt can be prevented. "In the Regent Steam Boat, they employed a method very successfully, that of pumping hot water through the boiler, and allowing a certain quantity constantly to be discharged from it into the sea; by these means the water was always kept in a sufficiently diluted state, so as to prevent its becoming saturated with salt, and consequently none could be deposited. No other inconvenient effect was produced than a greater consumption of fuel. The other mode is the common and ordinary one of taking out the whole of the water when the vessel arrives at the place of destination, and if there is any deposit of salt, taking that out also."

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In consequence of the injury which sea water does to iron, Mr. Cooke recommends that the air pump, buckets, rods and valves should be made of copper or brass.

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It is necessary that great care should be taken in selecting coals to be used in Steam Boats; they ought to burn free and become complete white ashes, without caking on the fire bars. Mr. Brown says, "that in the first passage he went in the City of Edinburgh to Leith, they were obliged to clear the fire every four hours; but having got a better description of coals at Leith, called Halbeath Main, they went, in coming back, sixteen hours without clearing the grates." Mr. Donkin says, "I think the coals ought to be particularly attended to; first, the kind of coals, and secondly, to avoid taking small coals, so long as the common fire-places are used; small coals occasion great waste; and all coals employed for Steam Boats ought to be screened." There is another reason why attention should be paid to the selecting and managing of the coals, arising from their tendency to fire spontaneously, if put together in large quantities in a damp state, and then exposed to the heat of a Steam Boat.

It will be seen by the evidence, that the consumption of fuel differs very much, according to the various plans on which the engines are constructed, even where the steaming power is the same.

In adapting the quantity of steaming power to vessels, the object, as yet, seems to have been to obtain a great degree of speed in smooth water. But this principle, in respect to sea vessels, is clearly an erroneous one; for the proper object is not so much having great speed through smooth water, as a certain progress, even at a very moderate rate, against a head sea in a heavy gale of wind.

The quantity of power sufficient to accomplish this is that quantity which should be applied to every sea boat, if her size and draught of water will admit of it. Mr. Donkin says, "from the observations I have made in most vessels, I have found them to have too little power for the size of the vessels;" he recommends that the engines should be made considerably larger than necessary for giving the vessel the required velocity in still water: he says, "there is no other disadvantage from increasing the power of an engine than the room it requires and the expense; but to counterbalance these, there is an advantage in not being obliged, at all times, to work the engine up to the extent of its full power; less fuel would be consumed, and the engine would be less likely to go out of order."

Mr.

See Evidence of
Mr. Donkin, p. 170.
and of Mr. Fara-
day, p. 190.

Mr. T. Beames says, "you cannot have too much power; indeed it is always of advantage to have as much power as can be obtained." Messrs. Maudslay and Field say, "with regard to the quantity of power proper to put into a sea vessel, the only limit should be the weight of the engine and fuel the vessel will carry and contain; no vessel ever had too much power, even in still water, much less when contending against a heavy head wind." "Two engines," they go on to say, "of half the power each, are more manageable, and possess many advantages over one of the whole power; they produce a perfectly uniform rotation in the wheels, and are not subject, like single engines, to be stopped on the centre in heavy seas; and in case of injury to one engine, the other is available."

It appears from Mr. Brown's evidence, that two fifty-horse engines will weigh from twenty to twenty-five tons more than two forty-horse engines; the weight of the latter, with coal and water complete, being one hundred tons. The additional expense would be about 1,000 *l.*; the expense of two forty-horse engines being about 6,000 *l.* According therefore to the opinions already stated, when a vessel will contain two fifty-horse engines, it will be decidedly better to have them of this power than two of forty-horse power.

Notwithstanding the great and rapid progress which Steam Navigation has made, it is still considered by the ablest engineers to be only in its infancy: experience suggests, in every new vessel and engine, some improvement to be made, or some defects to be removed. The numerous companies that have been formed in so many parts of the United Kingdom, have established an extent of competition which necessarily excites all the science of the country, to seize on every opportunity of making every thing better than it has been made before; and as the confidence of the public in Steam Boats leads to the general use of them, there is that fair reward for enterprising undertakings which will effectually sustain the general spirit which prevails amongst all the most scientific engineers, seamen and ship-builders, to invent further improvements.

It appears from the evidence, that attempts are now making by very ingenious individuals to remove some of those defects, which have been described to belong to the engines now in use.

Mr. Brunel is engaged on a plan for making the engine more compact and more simple, and at the same time stronger; and to enable it, by certain mechanical combinations, to adapt and accommodate itself to all the exigencies and to all the perturbations incident to its peculiar services.

Page 177, 178

Mr. Galloway and Mr. Perkins feel confident that high pressure boilers may be so contrived as to be used with the greatest advantage. Mr. Perkins, in his Answers to the Circular Queries, gives such strong evidence in favour of them, from the actual use of them in 150 American Steam Boats, as to go far towards removing the prevailing objections to them.

Page 188, 197.

Mr. Donkin is of opinion that a rotary furnace, on Mr. Brunton's principle, may be applied to Steam Vessels. This would be so very valuable an improvement, that Your Committee beg the attention of the House to Mr. Donkin's evidence on the subject: Q. Are you of opinion that this apparatus may be applied to engines on board ships?—A. Yes, I think with very great advantage; it probably would require a little variation in its construction.—Q. What are the general advantages of this plan?—A. The general advantages are economy of fuel and labour, and greater safety to vessels.—Q. In what way do you consider it would contribute to greater safety?—A. Because it prevents the continual operation of feeding the fire by hand, which requires the fire doors to be opened

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every five or ten minutes; and the frequent stirring of the fire occasions a great deal of the ignited coals to fall through the grate and upon the floor, whereas in this apparatus the coals are supplied by the machine itself, the fire doors need not be opened except about twice or three times a day.—Q. Does the fire produced by this apparatus act more regularly or powerfully than the fire supplied in the ordinary way?—A. Yes it does; small portions of coals are introduced on a revolving fire-place at certain intervals, so that the fire is regularly supplied; the combustion goes on entirely at the surface, and the incombustible matter, such as the vitrified parts of the coal and the ashes, settle down upon the bars, and protect them from the action of the fire." Your Committee have inserted in the Appendix to this Report the evidence given by Mr. Branton, concerning these furnaces, before the Select Committee on Steam Engines, of the Session 1820.

Mr. Oldham, of the Bank of Ireland, has invented a plan of revolving paddles, to avoid the defects of the fixed paddles as now used. He states, that the violent action of the paddles of common wheels, in striking the water in a rough sea, is entirely removed by the use of the revolving paddles, as they enter and rise out of the water with a peculiarly soft and easy motion. The precise merits of this invention will soon be ascertained, as these new paddles are now fitted to the Waterloo Packet, which plies regularly between Dublin and Liverpool, and to the Aaron Manby iron Steam Boat, lately sent from England to Havre-de-Grace, to be used on the Seine.

Mr. John Gladstone, of Castle Douglas, has invented another plan of paddles. He employs a pair of wheels at each side of the vessel, having two endless chains acting on them, with paddles fixed on these chains; and so far as the plan has been tried, on a very small scale, it has been successful. Several attempts have been made to get rid of the use of external wheels but hitherto without success.

Mr. Field has invented a flexible metallic piston, which has proved of great utility.

Your Committee have endeavoured to avoid all partiality in the arrangement they have made of the Evidence under separate heads, and, in their observations upon it; their object has been to bring as concisely as it was practicable, under the notice of the House, all the prominent advantages and defects belonging to the actual state of Steam Navigation at sea; with the opinions of the most scientific professional men upon the best means of improving it. If the frequent reference to the performances of the Post Office Holyhead Packets should give rise to an impression that Your Committee consider them superior to other Steam Boats, Your Committee desire it to be understood that they do not think any comparison can be fairly made between these vessels and any hitherto built by private companies. In the first place, the funds for constructing them being the public money, admitted of a scale of expense that private companies could not be expected to incur; and, in the next place, those vessels were built for voyages to be commenced at a fixed hour every day in the year, across a sea exposed to strong tides and heavy gales; that is, for a duty entirely different from the duty of common Packets. From the description which has been given to Your Committee of the new Liverpool Steam Boats, the St. Patrick and St. George, the Committee are led to expect that these vessels will prove superior to the Holyhead Packets, if they have been built of equal strength, in consequence of the great power of their engines, each being provided with two fifty-five-horse engines.

The merit of first applying Steam Engines to Sea Navigation is certainly due to the skill and enterprise of the Engineers and Shipbuilders of the Clyde;

Clyde; for it was, unquestionably, the success of their Steam Boats on the Holyhead station which led the Post Office to establish their Boats for keeping up the communication between the two countries. At the same time it is but justice to say, that the public are greatly indebted to the Post Office for having exercised such a sound judgment in directing their vessels to be built of that great strength, which has been so often mentioned in this Report; and which at the same time that it has been the cause of their complete success, has also established a new principle of certainty and security in the system of Steam Navigation.

IV. SAILS.

It does not appear to Your Committee that there is any probability, at present, of applying sails to Steam Boats in any more effectual way than they are now used. Captain Rogers says, "they assist a vessel very much; that they can be used at all times, except within four points of the wind, and that they serve to keep the vessel steady." He recommends a large lug sail forward, a jib and fore and aft mainsail; to have a square topsail on board, and a gaff topsail aft; with means of setting a topmast, but not to use it unless the engine was out of order. Several plans have been tried for getting the wheels out of gear, and for moving the paddle boards from the extremity of the wheels towards the centre, and some of them successfully. By these means, a vessel, in case the engine cannot be used, may be sufficiently well managed with the sails, as to carry her safely into port. The evidence of all the other witnesses goes to show, that any attempt to carry canvass beyond a certain moderate quantity will be attended with a great impediment to the steaming power.

THE great importance of a thorough acquaintance with every thing belonging to Steam Navigation, for securing a certain and rapid conveyance of the public correspondence, where seas are to be crossed, has induced Your Committee to take this general view of the whole subject as a preparatory step to coming to that part of the order of the House which requires your Committee to examine into the conveyance of His Majesty's Mails between Holyhead and Howth.

Your Committee consider the information which has been given by so many distinguished practical engineers and shipbuilders, as extremely valuable, and that every praise is due to them for the readiness and zeal with which they have contributed to render the inquiry of Your Committee of general utility. Not only the Post Office, but all private companies engaged in Steam Boats, may obtain great assistance from opinions derived from such extensive sources of science and experiment; at the same time that the public will be benefited by those various improvements which they suggest, and which will be the natural consequences of the persevering efforts of the great talents which distinguish these professions in Great Britain.

Your Committee, in expressing their opinion in respect to the proper establishment of Steam Boats at Holyhead, concur decidedly with the great majority of the witnesses who say, that not less than four Steam Boats ought to be employed on this service. They recommend, that the vessels should be built of very strong timbers, put together, filled in and diagonally fastened according to Sir Robert Seppings's plan; and that they should be coppered and copper fastened throughout. They approve very much of the plan of a Steam Boat as described by Messrs. Maudslay and Field, who say, "a Steam Vessel and Engine to encounter a gale that would bring a stout Frigate under her double reefed topsails, or a good Cutter under

under a three reefed mainsail, should be a vessel of about two hundred tons; both vessel and machinery exceedingly strong; her form, under water, that of the fastest schooner; the centre of gravity kept as low as possible; the projecting works on the sides added to the proper body of the vessel; the rigging to strike completely; the chimney formed to cut the wind; with two fifty-horse engines every way proportioned to the strength of the vessel." Your Committee conceive the evidence, which has been given before them, removes all doubts in respect to the practicability of putting engines of this power in a vessel of 200 tons.

Your Committee are of opinion, that every part of an engine for a Holyhead Steam Boat, should be made of wrought iron, except where there is no risk of breaking, and should be effectually proved before using it, by a proper proving machine; that the boilers should be made of copper; and that the air pump, buckets, rods, and valves, should be made of copper or brass.

Your Committee particularly recommend, as indispensably necessary for economy as well as safety, according to the opinions of all the witnesses who were examined to this point, that a professional engineer should be employed to reside constantly at Holyhead, to superintend the machinery and inspect the engine-keepers. And also that each vessel should be supplied with an extinguishing fire engine, and with two large boats in addition to the ordinary ship's boat.

From the great advantages which may be derived from revolving furnaces, Your Committee feel anxious that a proper experiment should be tried to ascertain whether they can be used in place of the common fire-places.

Your Committee consider the fares charged for the Holyhead passage much too high, and they are fully convinced that a much greater revenue would be obtained if they were reduced. The following Table shows the fares now taken, and the fares which Your Committee propose to be charged in future.

	Present Fares.			Proposed Fares.		
	£.	s.	d.	£.	s.	d.
Cabin passengers and female servants	1	5	-	-	15	-
Deck Passengers	-	-	-	-	7	6
Foremast passengers	-	5	-	-	3	-
Children under 10 years of age	-	12	6	-	7	6
Men servants	-	12	6	-	5	-
A coach, barouche or landau	3	5	-	1	1	-
Shipping ditto	-	10	6	-	2	6
A chaise	2	10	-	-	15	-
Shipping ditto	-	10	6	-	2	6
A two-wheeled carriage	1	10	-	-	10	6
Shipping ditto	-	5	-	-	2	-
A horse	1	10	-	-	10	6
Shipping ditto	-	5	-	-	2	-

The passengers to pay the steward, and to be at liberty to refuse to pay shipping-money in case of any misconduct of the sailors. The sailors to receive the shipping-money. The charge for shipping-money to include for shipping and landing each article.

Sailing Packets must still be occasionally employed. Your Committee are of opinion that their equipment and condition should be as complete as they were formerly; and that any person wishing to hire a Sailing Packet may be allowed to have one on paying ten guineas, or the regular rates, if they would exceed that sum.

The

The Committee of 1819, in their Fifth Report, particularly noticed the searching of passengers luggage, and stated their opinion in the following words: "Your Committee strongly recommend, that the Lords Commissioners of the Treasury should issue orders to the Commissioners of the English and Irish Customs, to make arrangements for discharging the luggage of passengers on board the Packets immediately after their arrival at Howth and Holyhead, without opening it; provided a certificate is signed by the owner of it, that it contains no goods subject to duty; except in such cases where a just cause may appear to the officers to lead them to suppose that the luggage contains contraband goods." It appears that no measures have been taken in consequence of the recommendation of that Committee, but that all luggage is carried from the Packets by the Custom House boatmen to the Custom Houses, and there searched. At Holyhead the luggage is carried, by the boatmen, from the Custom House to the hotels, for which they charge at the rate of one shilling for each trunk or portmanteau, and for small parcels sixpence and three pence per parcel. See App. p. 205.

Your Committee are desirous to express, in the strongest manner, their entire concurrence in the opinion of the Committee of 1819. They conceive it to be nearly impossible that the interests of the revenue could be injured by any contraband dealings. The proposed certificate would be a sufficient control over all persons who were mere travellers, and the right of the officer to search, being continued in all cases of suspicion, would afford ample means of detection in case of premeditated fraud.

But if this vexatious practice of opening every portmanteau, travelling-bag and dressing-case, shall still be considered by the Customs departments to be of such paramount importance to the interests of the revenue, Your Committee see no reason why the luggage should not be discharged on board the Packets. The size of the Steam Packets affords sufficient space for this business. The cabins are larger than the Custom House rooms either at Holyhead or Howth, and, in fine weather, the deck would allow of arrangements for the most effectual examination of the luggage.

Your Committee have been informed that the Custom House boatmen at Holyhead do not conform to the charges stated in the return of the Custom House, but demand one shilling for each parcel, however small; it may be. It is certainly a convenience to the public, so long as the present system exists of searching luggage at the Custom House, to have it brought there, and from thence to the inns, by the Custom House boatmen; but their charges should be clearly defined and published, so that it may be known what is right to be given to them. Considering how great the number of packages is that must go through their hands, sixpence for each trunk or portmanteau, and three pence for every other parcel, would be a very ample allowance for carrying them from the Packet to the Custom House; and as much more if they carry them to the Hotels.

It appears from the evidence of Captain Rogers, that the new Pier Harbours of Holyhead and Howth afford ample accommodation to the Packets. Fenders, and a better arrangement of the cranes, are still wanting at Holyhead. A vote having passed this Session for building a Graving Dock at Holyhead, this Harbour is likely to be complete as a Packet Station. The Breakwater proposed by the late Mr. Rennie to be constructed at Ireland's Eye, to protect the Harbour of Howth, has not been built: the strong opinion he always expressed of the utility of it, makes it particularly deserving of attention.

As the Boards of Commissioners, who were appointed by Parliament to superintend the construction of the Harbours of Holyhead and Howth, have now nearly fulfilled their duties; and as no Legislative regulations exist to provide for maintaining these works in proper repair, Your Committee are of opinion that a Bill should be brought in next Session for placing them under the same management that prevails at other Harbours.

As also the labours of the Commissioners appointed by Parliament for the improvement of the Holyhead Road, and for building the bridges over the Menai Strait and the River Conway, are drawing to a close, and as those works, which have cost so much public money, will require some permanent superintendence to preserve them from decay, it appears to Your Committee, that one Board should be formed out of the existing Boards for the management and maintaining of all these works, to have as the Chairman, of it the first Commissioner of Woods and Forests; and to be enabled to levy some small duties on Vessels frequenting the Harbours of Holyhead and Howth, in order to form a fund for the expenses which will be unavoidable in preserving them from decay.

It appears from the evidence of Sir Edward Lees, the Secretary of the Irish Post Office, that the various improvements suggested by the Committee of 1819, in respect to the Letters passing between England and Ireland, and other matters, have been adopted by the Irish Postmasters General. But Your Committee have been very much surprised to find, that one of the new regulations, which related to the conveyance of English letters from and to Dublin on Sundays, has been partially rescinded. The public have derived the greatest accommodation from removing the very unjustifiable detention of the letters for twenty-four hours in Dublin, according to the old practice; and Your Committee can see nothing like a reason, founded upon any principles of official consistency, or of an equal and fair distribution of the public correspondence, to warrant a measure that may save at most 350*l.* a-year, while it must be attended with very great public inconvenience. In place of thus limiting the operation of the Sunday Mails, Your Committee are of opinion that it ought to be extended, and that all the Cross Posts should carry the Sunday letters as well as the regular Mail Coaches.

Your Committee are informed that there is great delay in delivering the English letters in Dublin after their arrival there, and that it would be an accommodation to the public to extend the hour of delivery later in the evening than it now is, and to receive letters for England till a quarter before seven o'clock in the morning. It would be of great use to have a gun provided at Howth, similar to that on the Stack Rock at Holyhead, to assist the Packets in making the Harbour in dark weather.

12 June 1822.

MINUTES OF EVIDENCE.

<i>George Henry Freeling, Esq.</i> - p. 133 & 138.	<i>Mr. Bryan Donkin</i> - pp. 164, 168 & 195.
<i>Captain Rogers</i> - pp. 139, 143, 147 & 157.	<i>Mr. Mars J. Brunel</i> - - - - p. 173.
<i>Mr. James Brown</i> - - - - p. 147 & 160.	<i>Mr. William Evans</i> - - - - p. 178.
<i>Captain John Percy</i> - - - - p. 151.	<i>Sir Isaac Coffin, Bart.</i> - - - - p. 179.
<i>Mr. Joshua Field</i> - - - - pp. 152, 180 & 196.	<i>Mr. Michael Faraday</i> - - - - pp. 180 & 189.
<i>Mr. Timothy Bramah</i> - - - - p. 158.	<i>Charles Williams, Esq.</i> - - - - p. 181.
<i>Sir Edward Lee</i> - - - - p. 161.	<i>Mr. Alexander Galloway</i> - - - - p. 187.

Jeux, 21^e die Martij, 1822.

SIR HENRY PARNEILL, BARONET,

IN THE CHAIR.

George Henry Freeling, Esquire, called in; and Examined.

THE Holyhead Steam Packets have been principally under your management? — They have.

Be so good as to state to the Committee, generally, the course of proceedings which have taken place for introducing the use of steam vessels upon the Holyhead station. — The Postmasters General have been obliged to purchase all the sailing packets, and to clear the station for the introduction of those vessels; the object was, at first, to make the steam auxiliary to the sailing packets, but we found that the steam packets could do even more than the sailing packets, consequently we keep two sailing vessels as auxiliary to the steam.

How many steam packets have you employed? — We have three altogether, exclusive of the *Tartar*.

Be good enough to name them and describe them. — The *Royal Sovereign* of 210 tons, and the *Meteor* of 190; the *Sovereign* is fitted with two engines of forty-horse power each, and the *Meteor* with two engines of thirty-horse power; they were both constructed by Boulton and Watt.

Where were the vessels built? — In the river Thames, by a person of the name of Evans, at Rotherhithe.

Were they built purposely of any particular strength? — They were built on purpose for the service, under the inspection of the officers of the Navy Board; they were built upon Sir Robert Seppings's principle of the diagonal fastening, and made particularly strong.

What is the third steam vessel? — The third is the *Ivanhoe*, which was formerly on the Holyhead station as a private vessel.

What is her tonnage? — 165; the power of the engines fifty-six.

Is she as strongly constructed as the others? — No.

Was she used by the former proprietors for winter voyages? — She has been out in very bad weather, but has not been run the whole winter.

What has been the general effect of the experiment, in regard to maintaining a communication between the two countries? — The intercourse has been very much facilitated; it is now almost reduced to a certainty. In the year preceding the introduction of the steam vessels, a hundred mails exactly arrived in London after they were due, and in the nine months that the steam vessels have been running since May last, there have been twenty-two only.

Those nine months include the winter months? — Yes; when we have had much worse weather than the year preceding. The paper I have before me will more fully explain this.

[*The witness delivered in the paper, which was read as follows.*]

"From the Return made to the Order of the Committee on Holyhead Roads, of the number of voyages performed by the *Sovereign* and *Meteor*, it appears,

*G. H. Freeling,
Esq.*

(21 March.)

*J. H. Keeling,
Esq.*

(31 March.)

appears, that in a period of 265 days to the 20th February last, they have made 205 passages only.

"The remaining 60 days may be thus accounted for;—

The Talbot was on duty	-	-	-	16 days.
The Ivanhoe	-	-	-	6 "
The Tartar	-	-	-	8 "

"In 30 instances no steam packet left Holyhead, in 11 of these whilst the steam packets were under repair the mails were dispatched by sailing vessels, which effected the passage, in four instances, in time for the departure of the coaches from Dublin.

"In the other 19 instances, the weather prevented any vessel from putting to sea, or forced the steam packets back after having put out.

"Twenty-five mails have been brought from Ireland by sailing packets.

"The steam packets have been too late for the Liverpool mail in about 40 instances, and the London mail has been out of course in 22 cases only."

How was the weather this winter at Holyhead, as compared with other winters?—I understand that the weather, the beginning of the winter, was worse than has been known for more than sixty years. We have proof that the steam packets will go to sea in weather when sailing packets could not have gone to sea; the captains have always considered that it would not be prudent to go to sea, if they were obliged to be under a three-reefed mainsail, and the steam packets have gone out in weather in which the sailing packets would have been obliged to be so.

Were they able in those cases to make their passages in a reasonable space of time?—Yes; the longest passage, I think, was seventeen hours and twenty minutes.

Was that in a gale of wind, with the wind adverse?—Yes, decidedly.

What was the shortest passage?—Five hours and thirty minutes.

What is the average of the passages of the Sovereign from Howth to Holyhead?—Six hours and fifty-seven minutes, and the Meteor seven hours and four minutes and a fraction. To Howth, the Sovereign seven hours thirty-six minutes and a quarter, the Meteor eight hours and thirteen minutes: the shortest passage was from Howth, five hours and thirty minutes.

Do the steam packets sail at all times from Holyhead, notwithstanding a bad gale of wind?—Sometimes the weather is so bad they cannot venture to put out.

By what regulation is the point determined, whether the packet shall go to sea or not?—The captain reports to the agent, and if the agent is not satisfied, his instructions are to send out another captain in charge of the packet, if he will go; if both refuse to go, nothing of course can be done. There are three or four instances in which they have put out, and found they had not head-way, and of course it was better to come back than to attempt the passage.

Do they usually steer in the face of the wind?—The best point for a steam vessel, in very bad weather, is directly head to wind; both wheels can then act at the same time. The captains sometimes keep the vessel away, when it is blowing very strong, two or three points; then, when they get on the opposite coast, they will take in their sails, and steam to the harbour in smoother water.

Do you not conceive that the success of those two vessels, the Sovereign and the Meteor, is very much to be attributed to the superior manner in which they were constructed?—Decidedly.

Do you think any steam vessels, you are acquainted with, could have gone through the same difficulties that they successfully encountered?—I have attempted to gain some information about every steam vessel which has been built, and I am convinced those vessels will do what no other vessel can do; they will go to sea in weather when nothing else can. I attribute that not only to the machinery, but to the weight of the hull; a lighter vessel in a heavy sea would be checked, but those vessels have from their weight a momentum so great, that it carries them on when a lighter vessel would have been checked; the weight acts as a fly-wheel.

The weight they have arises from the great quantity of timber and copper used in the construction?—They are filled in solid, and they are nothing but masses of wood and copper.

To what height are they built solid on the sides?—I cannot state that.

In speaking of the tonnage of those vessels, do you mean the tonnage of the vessel estimated according to the rules applicable to other vessels, or the cargo these steam vessels are capable of actually carrying?—On the rules applicable to common and ordinary vessels.

Those

These vessels are coppered and copper-fastened?—Yes.

Every thing has been done to render them as secure and strong as possible?—Certainly; I have the authority of Mr. Lang of the Navy Board for stating that, with the exception of the discovery ships, there are no vessels so strong.

Is it your opinion that three packets are a sufficient number for maintaining the communication between Holyhead and Dublin, so that two shall sail every day?—Yes.

What is the arrangement with respect to allowing sufficient time for looking over the engines and keeping them in repair?—With the view that there might be a sufficient time allowed for looking over the machinery and the vessels, it was arranged that they should each be six days at sea and three days in harbour, which affords ample time for inspecting the machinery; that has been fixed in a great measure with reference to the engineers themselves, who stated that that time was more than sufficient for it.

Under whose care are the engines?—Under the charge of the engineers. When the packets were first established, as it was at so great a distance from London, we wanted men, not merely practical engineers, but having a greater portion of science than men of that description generally have, we were obliged to give very high wages, but we got certainly the two best men there were; we were obliged to buy them out of their situations in the River, one for each of those two vessels, the Meteor and the Sovereign. As the Ivanhoe might perhaps be merely a temporary vessel, we got the engineer who was with her from Liverpool, but of course we shall obtain the best engineer to be procured when a third packet is regularly established.

Each engineer has charge of his own engine?—Yes.

In what manner is the packet commanded?—There are four captains, who take it in turn; there being three vessels, each has charge of the vessel going the six days in turn, and once in a month the captains go off duty for eight days—the fourth allows a relief.

Is the engineer under the command of the captain?—Yes; certainly.

How many men are there on board each?—At present, as there are only two vessels, there are sixteen men on board each; as the work is very severe, there being only two vessels running every day, the complement for them, when a third is upon the station, is fifteen for the Sovereign, being the larger vessel, fourteen for the Meteor, and fourteen for the Ivanhoe.

What work do you allude to?—The going to sea every day, and clearing the boilers, and putting the vessels in proper order.

What time does that take after each voyage?—It takes a good while in the whole, as the boiler must be allowed to cool; the cold air must not be let in; it was found to crystallize the salt and injure the boilers, and we were obliged to cease doing that.

The seamen have not much spare time after a long voyage before the commencement of a fresh voyage?—In moderate weather they have.

There have been some accidents to the engines?—Yes, there have; but I hope that will be prevented in future; it was, I think, I may say almost entirely, to be attributed to the use of cast iron; the cross bars and the beams were of cast iron, and if any water was in the cylinder at starting, the check caused the cast iron to break; we have now got them made of wrought iron, but the lower beams of the engines, which are very large, are still of cast iron; there must be some part of the engine left to give way in case of any emergency, which is better than destroying the cylinder.

Have you altered those parts which were faulty?—Yes.

Since that there have been no accidents?—There has been one I think.

There was an accident in the summer with a beam?—Yes; they were of cast iron and hollow, since that we have got solid shafts of malleable iron.

Are the sails sufficient to navigate the vessels in case the engines fail?—Scarcely; there is sufficient to do it in case of emergency, but we have been trying experiments on the Dover station with different sorts of sails, and we find lug sails are more powerful than any others, and we have now sent down lug sails for the Holyhead packets instead of their fore and aft sails.

Is there any prospect of their being effectual to enable a packet to beat to windward?—A packet is so large a vessel it would not enable her perhaps to fetch to windward, but she would be able to reach some port, but there being two engines they can be disconnected, and one worked without the other; it has happened that a packet has proceeded using one engine only.

G. H. Freeling,
Esq.
(31 March.)

G. H. Peeling,
Esq.

(11 March.)

That is in case the main shaft does not break?—Yes.

You mentioned that the vessels were exposed to injury from Holyhead Harbour being so crowded; how has it been in the course of the last winter?—It has been frequently very much crowded; some time since two large brigs broke adrift in the harbour, and got foul of two of the steam packets; they did not do any very great injury.

It happens frequently in a gale of wind, that a great number of vessels come into harbour at Holyhead?—Yes, a very great number.

More than the size of the harbour is able on the sudden to accommodate?—Yes.

Have you any accommodation yet in the way of a graving dock?—No, I wish we had; it would be a very great object indeed for our service if there were to be a graving dock at Holyhead; at present they must go either to Liverpool or Milford; and Boulton and Watt, who furnish the machinery, are very anxious we should not go to Liverpool in case of accident, lest their competitors there should obtain possession of some of their machinery.

You have two sailing packets?—Yes; one stationed on each side.

Do they change?—They go across occasionally, once a week or a fortnight.

Are they commanded by a regular captain?—No, the mate is in charge; the mates who are selected for that are the most respectable men in the service.

What crew have they?—The sailing packet at Howth is fully manned; I think there are nine persons on board, including the mate.

Do they carry the mails?—Yes, when there is no steam packet; that at Holyhead has only four men as her regular complement, because we can always get enough people on a sudden to man her completely to go over.

Do they cross the Channel on any fixed days?—No; there are no fixed days.

Can any person hire a sailing packet that pleases?—It has never been made a question of; but it would be an object not to let them go lest an accident should happen to the steam packet expected next day; if there were three steam packets I conceive there might be no difficulty in allowing any person to hire one of them at Holyhead.

You have mentioned that there are only two steam packets at present that have been built particularly for the Holyhead service, the *Meteor* and the *Sovereign*; is it intended to build a third so as to make up your complement of three?—The Post-masters General have long had under consideration the building a third vessel, but when the *Ivanhoe* was purchased they wished to have a proof of what she could do before they began to build; they do not expect that the *Ivanhoe* will be found sufficient to run in the winter, and I believe measures have been taken for building a third vessel specially for the service, as far as regards obtaining plans and estimates.

Do you look forward to any improvements in constructing the new one?—I think the shape of the vessel can be improved to give her more velocity.

Which of the two is reckoned the best, the *Sovereign* or the *Meteor*?—It is hardly possible to draw a fair comparison, one of them having twenty-horse power more than the other; the bow of the *Sovereign* is infinitely superior to the bow of the *Meteor*, but the quarter of the *Meteor* is much better than the quarter of the *Sovereign*; if we could take the bow of the *Sovereign* and the quarter of the *Meteor* we should make a perfect vessel.

Has the experiment led you to expect that an eighty-horse power engine is preferable to a sixty?—I think the sixty-horse is preferable if the vessel is built a little finer with a foot less breadth; a good engine with a sixty-horse power would drive that vessel as fast as the *Sovereign* with her eighty.

What would be the effect with regard to heavy seas and bad weather?—She would be equally calculated for the bad weather. We find of the *Sovereign* and *Meteor*, the *Sovereign* is the best vessel going head to wind from her power; but in blowing weather with canvas, the *Meteor* is certainly superior. When we were going round to Holyhead from the River, we had some very bad weather off Beachy Head, and while the *Sovereign* was labouring in a sea, both under canvas, the *Meteor* shot by us; I thought she would have been down upon our deck; almost when we got round the Lands End, the weather was so extremely bad that we had hardly head-way, and we thought we should have been driven up to Bristol, fortunately the wind moderated and we were able to get into Milford. We were so anxious to get round the vessels, that the *Meteor* left the River in a very incomplete state; we had shipped several people in the river Thames who were sick and useless, and when we came to the very worst there were only four people on board the

Meteor

Meteor who could stand on their legs; considering all circumstances this could scarcely be taken as a fair trial, but on the whole the Meteor did as well as the Sovereign.

G. H. Fierling,
Esq.

(21 March.)

Both vessels put into Milford?—Yes. The Postmasters General, I believe, have some idea of trying whether what are called Scotch engines may not be better for a third vessel, in case of one being built; they are more simple though perhaps not quite so efficient, not so liable to derangement, and are consequently better for a heavy sea; and if the vessel is properly built, I do not think there can be any great difference in the rate of speed.

Inform the Committee in what the principal difference consists between the Scotch engines and Mr. Watt's?—I am not able to answer that question.

Is there not a difference in the paddles?—Yes, there is a difference in the way of fastening the paddles; we have tried the principle of the Scotch wheel at Dover, with machinery of Boulton and Watt, but we do not find it makes any material difference.

Have any of the Scotch vessels gone through the winter?—I believe not; the Rob Roy has been running occasionally between Dover and Calais in the winter.

You have a post-office steam packet between Dover and Calais?—Yes, two.

Have they gone through the winter?—One of them has gone through the winter, the other has only lately gone round; but from their draught of water, and the difficulties of the harbour on each side, Calais and Dover being dry harbours, and their not being able to run into them at all times, the captains have not thought it prudent to go in such weather as the Holyhead packets have put to sea in.

Are they built on the same principles as the Holyhead?—The wheels of one are not upon the first motion; they are spur-wheels, but we find that will not do for sea-way, the crank is so much more simple.

Has any thing been done to assist the packets at Holyhead to get into harbour in bad weather?—A gun has been sent to the South Stack, and each of the steam packets is supplied with one, that in foggy weather, if they do not exactly know where they are, they can fire and the man at the South Stack answers them.

Is there the same arrangement at Howth?—I believe not.

You have tried an experiment at Holyhead, with an engine upon an entirely new construction, in the Tartar packet?—We have.

What has been the result of that experiment?—I must first say that the inventor has not carried into effect every thing he intended, therefore the trial may be said to have been made while she was in an incomplete state. The Tartar, as an experiment for our Holyhead service, has entirely failed; indeed Mr. Broderip admits she is not calculated for the Holyhead station; his object was to make the machinery auxiliary to a sailing vessel, that she should have all the properties of sailing with the power of applying machinery if the wind was contrary.

Then the failure has been more owing to the attempt of connecting the sailing power with the steam than any failure in the principle of the engine?—The engine is faulty in part certainly.

What is the postage on a letter from London to Dublin?—Fifteen pence.

What part of that is for crossing the Channel between Holyhead and Howth? Two pence.

What is the postage from London to Holyhead?—Thirteen pence.

Might not a vessel, constructed with all the properties of sailing, with the Sovereign's bow and the Meteor's quarter, have a steam engine put into her, and answer as well as the Meteor or the Sovereign?—Certainly, as far as the hull is concerned; the object is velocity through the water, whether the vessel be propelled by machinery or by canvas.

Are the boilers in those Holyhead packets high pressure or low pressure?—Low pressure. Mr. Watt, I believe, was the inventor of the original high pressure engine, but afterwards abandoned it on account of the danger.

No cases of late have happened of accident from the bursting of boilers?—Not that I am aware of.

The bursting of the boilers in either of those two packets would interfere with the action of the steam engine, but would not be attended with dangerous consequences to the crew?—The boiler would not burst, it would rend or open.

There could be no explosion?—No.

That arises from its being made of wrought iron?—Yes.

What precautions are taken to prevent accidents by fire on board the post-office steam packets?—There is a greater space; the engineers can get round the boilers

and

G. H. Freeling.

Esq

(21 March.)

and under them and over them; in addition to the outer case round the bottom of that part of the funnel which is near the deck there is a third iron flanch which comes from the funnel to the deck.

What number of boats is there in each packet?—There is only one on board at present.

It having been observed that the boat was on the deck, was that the proper place for her?—No; the proper place is hanging from the stern—there are davits for the purpose there.

Under whose care are the ladders at Holyhead from which the passengers embark or disembark from the packets?—I believe the commissioners of the pier.

How many feet at low water is it from the top of the pier to the deck of the packet?—Fifteen or sixteen feet, I think.

What description of ladder is made use of?—It is a very indifferent ladder; it is in my opinion scarcely safe.

Jouis, 28^e die Martij, 1823.

George Henry Freeling, Esq. again called in; and Examined.

(28 March.)

ARE there any alterations or additions you wish to make in the evidence which you gave on a former day?—I wish to explain some parts of it as to the steam packets, in addition to the securities I mentioned against fire; we do not put any fuel or coals over the boiler, which was the cause of the Robert Bruce catching fire and being burnt. They used to stow their wood and fuel over the boiler, which became ignited in some way; it never is done with us, it is positively forbidden.

Where are they stowed?—In cases made for the purpose in the engine-room.

Are the cases lined with iron?—They are iron cases. The other point was as to the *Levanhoe*. I was asked whether she was so strong as the other vessels; the answer was simply, "No." But she is not three years old; she was inspected at Liverpool a short time ago, and I think she is as strong as any of the steam vessels except those on the Holyhead station.

Was any thing done to her to make her stronger?—She was inspected and made as strong as possible under our direction.

What timber is she built of?—Fir.

Then it is the difference arising from the different state of the two sorts of timber?—Yes; and the difference of her filling in; she is not filled in as the others are.

Besides that is there a difference in the timber?—Yes.

Do you look upon it that the superior strength of the oak counterbalances the weight?—I think the weight is a great advantage. A question was also asked as to the practice of begging for money. I have ascertained that there is certainly no instance of the packet seamen having done this at all. There are men who were formerly in the packet service who attend as porters on shore, and being out of employment follow passengers and ask them for money.

You do not now allude to the steward?—I now allude merely to the sailors.

Is there any code of regulations as affecting the passengers delivered from the post-office?—There is no written code of regulations.

What accommodation is there on board the *Royal Sovereign* as to births?—There are twenty altogether.

How many rooms are there?—Two; one for ladies and one for gentlemen.

How many births are there for ladies?—Six.

The cabin appropriated to gentlemen is fitted up with sofas?—There are two sofas.

Is there any rule or regulation which prevents ladies going into that cabin if they find it convenient?—None whatever; but we rather wish to keep the after-cabin distinct for ladies, because when they are in bed they do not wish strangers to be there, but we find it impossible to do that. Gentlemen going over with ladies say, "Keep me out if you dare; my sister, daughter or wife is there, I will go in to take care of them."

Is there any regulation that if a lady was to wish for a pillow to support her head, that she could not have it?—I have never understood so; there is a regulation that the stewards shall not bring the beds upon deck; we have had a great number of beds spoiled from being brought upon deck in bad weather.

Captain William Rogers, called in; and Examined.

You are the commander of one of the Holyhead packets?—I am.

Be so good as to acquaint the Committee in what manner the communication has been kept open between Holyhead and Dublin by the steam packets, and what has been the success of the experiment of establishing them on that station.—We have done every thing that could be done by steam boats, and they will go no doubt when a sailing vessel will not; that has been proved.

Have they fully answered the expectations you had formed of them?—Fully so; they have exceeded my expectations.

Have you had full trial of the steam packets with respect to gales of wind?—Yes, in every way; I crossed in the Meteor on the 5th of February, in the heaviest sea I have seen during the eight years I have been on the station.

Have the steam packets sailed regularly the whole winter?—Except a very few days; I have seen them go several times when the sailing packets could not.

What have you considered to be the sort of weather when you say the sailing packets could not go?—I went in the Meteor on the 5th of February, when no sailing packet could carry canvas, they must have laid to; I left at nine at night, and arrived at six the next morning.

Was it blowing in the way you describe at the time of your leaving Holyhead?—Yes.

The sailing packet would not have attempted, under the same circumstances, to have gone to sea?—No one could have gone.

How came you to sail at nine o'clock at night?—There were two mails on board; the Tartar put back with the mail, and I took her bags.

In what point was the wind?—South-west and by south; no sailing vessel would have got under weigh at the time; the Chichester sailing packet came over the same day from Howth, with a three-reefed mainsail, storm jib, and could not bear a foresail, and it blew harder when we started.

How long was the Chichester coming over?—About seven or eight hours.

Why did you go at nine at night?—To prove what steam would do.

The Tartar had put back, and you had taken the mail she could not take?—Yes.

Are you not perfectly satisfied, from the experience you have had, that the steam vessel you command is capable of performing what no sailing vessel can do?—Yes.

You mean the steam vessels built for the Holyhead station?—Yes.

Have you not often left Holyhead, during the winter, when no sailing vessel could get out?—We have.

Have you discovered that the steam vessels, built under the inspection of the Navy Board, are as safe as any vessel you ever navigated?—Certainly.

Is there any danger, in your opinion, to be apprehended from them as steam vessels?—No.

In what way is your safety provided for in the shape of valves?—We have safety valves, but I cannot say how many pounds to the square inch.

If at any period the fire should elevate the steam to such a pitch, has not the engine the power of relieving itself?—It has.

Have you observed that, in crossing the Channel with an adverse wind, you accomplished your passage under easier circumstances than you could possibly do in a sailing vessel, inasmuch as you were enabled to go head to wind?—Yes, much easier.

Do you find that a steam vessel is capable of making her passage much sooner, under all circumstances, than a sailing vessel?—Yes, in one half of the time upon the average.

With the wind at W.N.W. blowing hard, and leaving Holyhead in a gale of wind, you have found a steam vessel has been much easier than a sailing vessel?—Yes, their extreme length overcomes the short sea.

Do you, with such wind, steer your course direct?—That depends on the weight of the sea and state of the tide. It is a general rule with me, when the vessel will steam from three knots to three and half, and the vessel not labouring much, to make a straight course; if otherwise, to sail her until I smoothen the water, then down all sail and steam right for the port.

Have you found in blowing weather that the vessel works at all either inside or out?—No, not at all; I do not see it in the least, not a single thing, she is as solid as a wall.

*Captain
William Rogers.*

(18 March.)

What do you attribute that principally to?—To the diagonal works, and to the mode of fastening.

Have you tried the coal tar?—Yes.

How long have you used it?—Ever since she has been built.

What is the longest time you have ever been on the passage?—Fifteen hours is the longest I have been.

Do you conceive that any improvement can be made in the construction of a steam boat should a new one be ordered?—Yes; I think we could make improvements.

State what they are.—I do not think too fine a vessel will do; when she is so very fine she will not answer in those seas; the bow of the *Meteor* is too full and the *Sovereign's* quarter is too heavy.

What improvement could you suggest to the Committee to do away that?—In building a steam boat she ought to have a fine entrance and her bow to flar off, not to shove any water before her; any water she shoves before her must be an impediment to the sailing; she should have a fine entrance, a good line of bearing, and her transom pretty square, and not too high; the more you can stop a vessel from pitching and rolling the quicker she will go; I found with regard to the Scotch boats that all their transoms were too high and too narrow, the consequence of which is, that with a head sea they go with their stern under; I have seen them go bent and every thing under; the transom being square and low and fine under, so as to give them a right line of bearing, will stop their pitching and rolling and make them easy on the sea and add to their speed.

You attended the building of those two vessels, the *Meteor* and the *Sovereign*, in the river?—Yes, I did.

Describe generally the cause of their great strength.—They are filled up solid to the floor-head, caulked inside and out, having no tree nails, but bolted and copper nailed. The bolts are driven upon a ring and clenched at both ends.

Have you Spanish heads?—Yes; then there is the diagonal fastening.

Describe what that is.—The diagonal fastening is a plank three inches thick fore and aft, three and a half thick midships, and nine wide leading from the floor-head to the shelf, taking in five or six timbers; and then it is filled by truss pieces into triangles, so that it is almost impossible that the form of the vessel can alter.

Have not these vessels proved themselves decidedly superior to any other steam vessels?—We have never seen any other steam vessels that would go with them; they are very superior to any others in strength, safety and speed.

Have you examined many steam vessels?—I have been on board several; the *Majestic*, the *Superb*, the *Ivanhoe*, and the *Talbot*, and many others in London river.

Have you sailed in any of them?—Yes, in the *Superb* and the *Majestic* from Greenock to Liverpool; *Talbot* and *Ivanhoe* from Houth to Holyhead.

Did you go to Greenock for the purpose of inspecting the steam vessels?—Yes.

Did you see and examine those other vessels previous to the building of the two *Holyhead* packets?—Yes.

Have any other steam vessels navigated and kept at sea all the winter?—None. The *Majestic* and the *Superb* had some difficulty in making their passages last October, and were laid up for the winter. I remarked on board the *Majestic* when I was in her that she was very tender.

Very crank?—Yes, very crank.

If you were consulted with respect to building a new vessel, what other alterations would you propose besides those you have mentioned with regard to the bow and the stern?—Their main beams might be put closer to the wheel, and their boiler placed lower, and the engines nearer together and more in the centre.

The engines on board those vessels were made by Boulton and Watt?—Yes.

Have you seen the Scotch engines?—Yes, I have.

Are you able to inform the Committee which engine is best?—I should prefer Boulton and Watt's engine to any other; their boilers are very superior, and never short of steam. Boulton and Watt had been accustomed to vessels for rivers, and the engines were made rather too slight for our Channel; the shaft was hollow, and of cast iron, but they have been replaced by solid shafts.

Have those vessels ever been disabled except when they broke their shafts?—They have broken their cross-heads, which are soon replaced. I broke two, and they were replaced immediately; the cross-head of the piston, and the cross-head of the air-pump, which were replaced with wrought iron spare ones on board.

Were those replaced at sea?—Yes; we stopped one engine and worked the other with the wind right a-head, and in five hours the engine was repaired and worked.

There

Captain
William Rogers.

(28 March.)

There is a difference of opinion between wrought iron cross-heads and cast iron; they say it is better for the cross-heads to break than any thing worse, which is the beams, or the top of the cylinder to be knocked off.

Then, in point of fact, since the month of May last, when these two vessels were put upon the Holyhead station, they have never been disabled, except in those two instances when the shafts broke?—No; and then they could have made their passage.

You are able always to keep one engine at work out of the two, unless the shaft fails?—Yes; you may always work one engine, unless the shaft breaks. The shaft is the only part common to both engines, and therefore unless the shaft is broken, the two engines are not disabled.

Comparing the Meteor and the Sovereign with any other steam boats you have seen, are they not infinitely superior both in construction and safety?—Yes; and in speed.

In a gale of wind?—Yes.

Have you ever exhausted your fuel?—Never half.

Do these engines consume much less fuel than the engines of other vessels you have been on board?—I should think less than half.

What is the rate of consumption by the hour?—We use about eight hundred weight in the Sovereign per hour; in the Talbot and Ivanhoe they each consume about fourteen hundred weight.

What does the Meteor consume?—About five hundred weight.

What are the respective powers of the Sovereign and the Meteor?—The Sovereign has two forties, and the Meteor two thirties.

Do you find the Sovereign a superior vessel in consequence of this increase of power?—Yes, in going head to wind; but there is a great deal owing to the Meteor's bows; she will not go head to wind.

Which vessel would you prefer in a gale of wind?—I think the Meteor is the best boat in a gale of wind.

Generally speaking, would you prefer an eighty to a sixty horse power in a gale of wind?—No; but I think the Sovereign is rather overpowered; if you were to put two forties in her again you must put in much heavier engines. The advantage the Sovereign has over the Meteor is going head to wind, but the Meteor will beat her with her canvas. The Sovereign's canvas steadies her and lightens the engine, but does not much help her speed.

Supposing you were choosing your own vessel, what plan would you prefer?—I think you might build the vessel a little smaller for two thirties; if we were to build for two forties we must build a larger vessel than the Sovereign, and she is full large for the station.

What size would be the best size for vessels for the station, and what power?—I think the Meteor is very near the size, with the improvements we could make upon her.

Under all the circumstances of your passages, have you not found the motion of the steam boat much easier than the sailing vessel?—Yes; it is not to be compared to it.

In a gale of wind have you found the passengers complain of the motion?—Yes, they do complain of the vibration; passengers frequently complain on board the steam packets that they were never sick before, but I do not pay much attention to that, for the last passage is always the worst.

In what degree are you able to take advantage of sails in bringing them to aid the steam power of the vessel?—Sails assist the vessel very much; we use them every way, except going head to wind, within four points of the wind.

Do you find them assist considerably in the speed of the vessel?—I have found the Sovereign go as fast in a calm as at any other time. It must not be thought that a steam boat running before the wind in a gale and a heavy sea, that she ought to make the quickest passage, as we are then obliged to shut off half the steam, or great part of it; for should you allow the full power to be on, the wheels running two or three times round without touching any thing between the trough of the sea, and then being brought up all at once, something will probably give way.

And by thus moderating the steam there is no fear?—No; the engine goes as easy as a glove.

Do the sails serve to steady the motion?—Yes; they steady her certainly.

Do you not make just as good a passage with a foul wind as a fair wind?—In a light air of wind we do not mind going head to wind, and smooth water.

Captain
William Rogers.
(28 March.)

Supposing the engines to be out of order when at sea, so as not to be able to use them, have you sails enough to enable you to command the vessel?—Yes. The other day when I have the Meteor to I stopped the engine, and we were going three knots and a half with the lee wheel nearly under water; we were sounding; it was very heavy weather.

Have you the power of putting the wheels out of gear?—You may unconnect them from the engine and let them run round, or take your floats off; but we cannot do that when the engine is going.

When you broke your shaft what did you do?—I was not on board her then, but I towed her back; I met her about seven leagues from Howth, and towed her back to Holyhead.

How was the wind blowing?—South-south-east, fair for Howth.

Do you think she could have got on with the sails?—Yes, and made her passage; but as the mail was sent away by a schooner to Howth, it was better to tow her back, as Holyhead was the only place to repair her.

A shaft has been broken twice?—Yes, twice; once in the other boat.

What was done in the other case?—She was towed back.

Supposing dark weather to come on, the wind blowing hard from the Irish shore, so that you could not have made the land, could you have hid to or sailed the vessel?—Yes, we could have sailed the vessel or have come to an anchor; by putting two cables together which she has on board, she would ride out any gale in the Channel as easy as a glove.

You are of opinion that in the event of the engine failing, with the assistance of sails and the anchor you may always keep the packet in perfect safety?—There is no doubt of it.

In the event of any accident happening to the steam apparatus with a lee shore, what power have you, by sails, of keeping off that lee shore?—I cannot see where there is a lee shore, it must be either over at Dublin or at Holyhead; and it is a lee shore, then it is a fair wind back.

Have you ever been in such a situation, since you have commanded those packets on a lee shore, that you could not take the tide under your lee bow on one tack or the other?—Never.

Have these packets the same power to go to windward as a common merchant vessel?—Yes, and they will beat a common merchant vessel in sailing.

Have any improvements been made lately to give steam packets more power of canvas?—Yes, there have been.

Explain what they are.—Three more cloths are put in the mainsail, and a very large fore lug; the after one remains a schooner sail.

Will you be obliged to carry more ballast in consequence?—No, we are as stiff as churches; we take out 12 tons of coal in the summer; there are 60 hours coal on board.

Upon the whole, with the nature of the Channel, the shores, and the power of the canvas you can put upon a steam packet, with the aid of anchors and cables, you feel perfectly secure at all times, though the engine may go out of order?—Yes.

Has it ever occurred to you to lay to for a night at anchor?—No, we never should lay to any where.

Have the packets ever been out a whole night, starting in the morning?—Never; one o'clock in the morning is the latest they have been out; you cannot lay to in a tide way, or ought not so to do; we do not want it; the people get more used to steam vessels now; we can hit the land at any time now, either the hill at Howth, or Holyhead light-house.

Have you guns on board for signals?—Yes, a six-pounder each.

There is a gun at the Stack?—Yes, there is.

Have you found it of any use as yet?—We have had no use for it as yet; we shall want it in the summer, I dare say; I have not the least doubt we shall find it of great service.

Is there any gun at Howth?—No; there are some on the round towers.

Not to assist the packets?—No.

From the superior construction of the Meteor, and the Sovereign having their timbers filled in and caulked, in the event of getting on shore and knocking the keel off, or the planks off the bottom, still the vessel might be saved?—Yes, certainly, there is a very great difference of opinion as to filling vessels in that way.

Have you found those two vessels equally buoyant with any other you have sailed in?—Yes.

Has

Has the great weight of the timbers and materials diminished their speed?—No, I think it rather gives them speed against a sea.

Then the inconvenience anticipated from the mode of constructing these vessels has not taken place?—No, it has not.

Are the Committee to understand your opinion to be, that in any weather, however severe, the steam boats will stand that weather as well as any sail boat?—Yes, in any wind; the more wind the better for the steam boats; that is where they show their superiority.

In the heaviest gale that could blow you would rather be in a steam packet than in a sailing packet?—Yes; that is in a vessel of our own construction.

Sabbati, 30^e die Martij, 1822.

Captain William Rogers again called in; and Examined.

BE so good as to give the Committee an account of your voyage from the River round to Holyhead.—On the 16th of May, blowing hard from the S.W. 3. P.M. I left Gravesend on board the *Sovereign*, in company with the *Meteor* steam packet, with seven or eight men on board of each. At 9 anchored in the Downs, blowing very hard; she rode very easy with thirty-five fathom cable in five fathoms water. On Thursday the 18th fresh gales from W.S.W. 5. A.M. weighed anchor and steamed for Portsmouth; wind dead on end. 4. P.M. made the Owers Light; hazy weather. 9. P.M. very heavy gales and thick weather. I asked the engineer what coals he had on board, he told me five hours; we were then obliged to steam in for the land. At 10 made the Nab Light upon the starboard quarter, about a quarter of a mile; shortened steam for the *Meteor* to come up. At eleven anchored at St. Helen's in six fathoms water, with forty fathom cable; hard gale. On the 19th, 3. 30. A.M. weighed anchor and ran into Portsmouth harbour; made fast to one of the buoys alongside His Majesty's ship the *Queen Charlotte*; then we were employed in getting coals in, and very bad they were. At 4. 20. got under weigh and steamed out of the harbour, and at 9 passed through the Needles against a flood tide. This day was fine weather, and light airs from the N.W. At 1. 30. P.M. anchored in Falmouth harbour; there we remained a week to clean the boilers, to caulk the decks, and so on. Sailed from Falmouth the 26th, wind N.W. fresh gales. At 5. 30. passed the Longships Lights. At 9 in a squall, with heavy rain, the wind shifted to the N.N.E. blowing very heavy and a heavy sea, the vessels going from three knots to three and a half, head to wind, blowing hard. At 7 made Lundy Island, bearing E. by S. passed several vessels lying to; passed a large smack, lying to, under close reefed mainsail. At 8 made sail upon the vessel; stood more to the southward into the Bristol Channel, to smoothen the water. At noon more moderate; water smoother; down all sails and steamed for Milford. At 5 anchored in Milford, found several vessels had been out in the gale and obliged to put back; the vessels that had been put back, bound to Liverpool, said they had never experienced worse weather before for many years. On Sunday evening the wind more moderate, and from N. to N.E. At 8 P.M. got under weigh. On Monday, at 4 P.M. arrived at Holyhead.

How many days were you performing this voyage?—Five days, with the wind right a-head down the English Channel and up the Irish.

During that period could any square rigged vessel, from a first-rate down to a sloop of war, have performed the voyage you did in the time you did in the steam boat?—No; it was impossible. In the Downs we passed several Indiamen, and 150 sail there that could not move down Channel, and at the back of Dungeness we passed 120 more.

During that period how did your vessel behave herself, under the circumstances of bad weather and adverse winds?—Nothing could be better; but she rolled a little, and which I think we can cure her of.

What improvement could you suggest to prevent her rolling?—I should take a foot off her beam in the first place, and make her bottom not quite so round, and the engines placed nearer together, and her wheels not quite so wide on the side; they are eight feet wide.

In a gale of wind on a lee shore, do you not think them much safer vessels than any square rigged vessels?—Yes, most certainly; because they can use their steam as well as their sails.

Be so good as to describe to the Committee the exact improvement you would

*Captain
William Rogers.*
(28 March.)

(30 March.)

*Captain
William Rogers.*
(30 March.)

recommend as to the construction of a new steam vessel.—I should make her a foot narrower, and raise her floor-heads a little, take off the roundings, with her engines put nearer the centre, the boilers much lower, and the wheels narrower: I have observed in our vessels with these wide wheels, the lee wheel is a great deal under the water, and the other out; by the width of them it increases the angle; and although a wide wheel is of great advantage in a river, I think it is a great disadvantage in a sea; supposing there were two forty-horse power engines, I would not have more than a seven-foot wheel; ours is an eight-foot wheel, and if there were two thirty-horse power, six and a half, in my opinion, would be sufficient.

Would those wheels have power to give the packets the same speed they have at present?—Yes; we might lose twenty minutes in a calm, but we should gain two or three hours in a gale of wind; that has been tried in this river by the *James Watt*; her paddles are nine feet wide, and with one half of them on, four and a half in length, she was found to go nearly nine knots, and she only goes ten with the whole on; but I must observe, that after you get a vessel to go nine knots, it takes a great addition of power to make her go the tenth.

As to the form and shape of the *Meteor* and *Sovereign*, what improvement would you recommend in a new vessel?—I should recommend it to be a little finer and eighteen inches narrower than the *Sovereign*, and a foot narrower than the *Meteor*.

What alteration would you propose with regard to the bows?—Much finer than either of them.

Have you sufficient experience of the Scotch engines as to be able to give a decided opinion in favour of the engines made by Mr. Watt?—No, I have not yet. I have been in the Scotch vessels several times, and I have seen their steam go down; in one of them the vessel was nearly on shore; it was the *Majestic*; she was entering the narrow passage going into Liverpool, and they let the steam go down; she was nearly on shore in consequence; unless you are constantly firing you can never keep the steam up.

Has that ever happened on board the Holyhead packets?—No; never.

On building a new vessel, would you recommend Watt's engine to be made use of?—Yes, I would, for my own part.

Can you suggest any improvements?—I should make the engine much stronger. In what respect?—In every part.

What effects have you observed, when on board the Scotch vessels, from the engines?—I have seen fire going up the chimney, and I have seen sparks of fire flying over the deck; there must be a great waste of fuel in consequence; we never see that on board our vessels; they come out clearer, but they are cheaper in the end.

At the time you performed that voyage, with the weather you have described, from the Downs to Milford, if that weather had continued twelve months, would any square rigged vessel have performed it?—They would have been a long time about it, probably would have been weeks instead of days; a sailing vessel would not have beat up to Milford as we did in twelve months.

What parts of the engine give way most frequently?—The cross-heads at the top of the piston. If the engineer is not very careful, and allows them to get too hot, you may carry away a cross-head, or if water is allowed to get in the piston, which it does sometimes, being too hot. I think there will be an improvement in that before long.

What time ought to be allowed, in your opinion, for looking over a steam engine in order to keep the vessel as much at sea as circumstances will admit of?—Two or three days. An engine should never lie by longer, because if she was to lie by in the harbour, you would have to set the engine going to keep it in order.

Does it require three days to give an engine a complete looking over?—No; two days, or a day, or two or three hours; it is according to what is to be done to her.

What number of days may a vessel sail, day after day, without a thorough examination?—They might run a week, fortnight or longer, but once a week it would be necessary to examine them.

You recommend she should lie by two or three days, and be examined?—Yes.

Then, on the Holyhead station, it being necessary to send a packet to sea every morning from Holyhead, and another from Howth, in order that the vessels may be kept in order, how many vessels, in your opinion, should be maintained to do the service?—I think you might do it with three, and very easy, with a sailing vessel on the other side; then a vessel would be lying by three days and running six.

With those arrangements of lying by three days and being at sea six, three vessels would

*Captain
William Rogers.*
(30 March.)

would just exactly perform the service, and no more?—No more would be required; they would perform the service; nor is it necessary they should lie by three days.

Supposing they sailed six days and laid by three, there would be no day on which they were not at sea or lying by for the necessary time for examination and repairs?—It does not follow that they would want repairs.

Supposing they do lie by three days and are at sea six, it occupies the whole time, there is no spare time?—The spare time would be the three days.

If each packet is at sea six days, and if she lies by after every six days for three days, she would actually upon no occasion lie by more than three days?—Certainly not, unless there is any thing particular to do to them.

Three packets would just perform the service, and nothing more?—Yes.

But upon a press a vessel would go eight days instead of six?—Yes, we have gone all the winter and summer with two.

Since the Meteor and Sovereign have been at Holyhead, have they not been continually at sea?—Yes.

How many men are there on board?—Fifteen.

What work have the men to do after the packet arrives at either side?—They get the coals in, and clean her.

What time does that take?—About a couple of hours with horses and carriages.

Have you not made many voyages in succession in gales of wind?—Yes, many.

Coming in late after a gale of wind, and having to sail early in the morning, do not the men go through a great deal of hardship while the weather continues bad?—Yes, but they have their night's rest; if a man be in a sailing vessel, and should be on deck two or three nights, he would soon find the difference to a steam vessel.

Do you not think the work is as hard on board the steam packets as the sailing packets?—Certainly not, as regards myself.

As to the men?—Nor as to the men; if a man complains of a steam boat, he must be afraid, or something of that kind. I never read a novel before I was on board a steam packet, and I go down now frequently and read for an hour or two; if a man works hard in the day, he has his night's rest, and a man is never better than when he does his day's work; I have not the anxiety now which I used to have, being up night after night.

In what way is it decided whether a packet shall go to sea in case of very bad weather?—By the commander and the agent.

What is considered to be weather to keep a steam packet from going to sea?—There may be a difference of opinion upon that; when it is a downright hurricane, and it is impossible for any vessel to stem ahead, we do not attempt it.

Do they go out when the cutters cannot?—Yes, with the wind at N.N.W. which is the very worst wind we have.

Do you go out when a sailing vessel would not?—We have made many passages when a sailing packet would not go out.

Were there many gales from the N.W. last winter?—Yes, several.

Has it been a worse winter than usual?—I have heard it said, that it has been the worst winter for fifty years. Lloyd's have paid more this winter than ever they did.

Have the gales been from the S.W.?—Yes, S.W. and W.S.W. and that generally finishes with a N.W. wind.

Have you had many from the eastward?—No, only one gale.

Which do you reckon the worst gale?—I think meeting with an easterly gale is the worst; there is always a heavy sea upon the shore, the gale does not last so long, but leaves a very disagreeable short sea. Many times after an easterly gale, we have been two days beating over in a sailing packet, which a steam vessel will perform in eight or nine hours.

Have you ever sailed in a heavy easterly gale from Howth in a steam packet?—No, I have not; the Meteor, Captain Davies, entered Howth harbour with a very heavy gale from the eastward, when the Marquis Wellesley went over, and she went in very easy. It was the heaviest sea that had been seen for many years.

Has the harbour at Holyhead been crowded very much with vessels?—Very much; I have seen 120 or 130 vessels there.

Have you experienced much difficulty in getting in or out with the packets?—No; but the Sovereign has suffered some damage with vessels driving upon her.

Is the harbour large enough for the number of vessels that have recourse to it in bad weather?—No, I do not think it is.

Is it not the practice frequently for the Liverpool vessels to run in?—Yes; but when

Captain
William Rogers.
(30 March.)

when Duncary is finished, I am of opinion that will be the out port of that Channel. There have been several instances of vessels leaving Holyhead, and have gone there to wait for a wind, which have made their passage out of the Channel, whilst the vessels at Holyhead have still been wind-bound.

Have you found any difficulty in bad weather in getting the packets into Howth harbour?—Never.

Have they ever touched ground there?—Very seldom. They are deepening it in the west pier.

Have any of the vessels been damaged by touching?—No; the sailing vessels used to be.

Are there any inconveniences in landing passengers and carriages at the pier at Holyhead?—Not passengers, but carriages. I have seen Sir Colin Campbell's carriage detained on board the Sovereign for twelve hours for want of a crane being in the proper place.

Where is the crane?—Half the pier up one of them is, and the other is down in the jetty.

Where would you propose to put the crane?—About 120 feet from the jetty. There are no fenders, and we run a very great risk of breaking the wheels or destroying the engine, for want of them; no longer back than last Sunday, we nearly met with a very serious accident, by striking the foundation stones at low water; I did hear before Mr. Rennie died, there were orders given for them, but have not heard a word about them since.

Are the cranes in a proper situation at Howth?—Yes; they have got two, and a third, a temporary one.

Where are they placed?—One on the west jetty, one abreast of the Custom-house, and one on the east pier.

Are there fenders at Howth?—There is every thing complete there.

Would not an extension of the harbour at Holyhead, so as to admit the Liverpool traders to come in, be of considerable value and importance?—O! yes.

Have the East and West Indianmen any port to run into between Milford and Liverpool?—No; Holyhead might be made one.

In case of an accident in the Channel, where must they go to repair?—Liverpool.

Is there a sufficient depth of water for forming a pier at Holyhead, so as to make it a harbour for the general trade?—Yes; between the point of the salt island and the present pier, there is a large rock, which would be a good place to run a pier from, with plenty of water to take any vessel.

And such a pier would give perfect protection to the largest vessels that come in?—Yes.

How long would such a pier be?—Half the length of the other.

In what manner are horses put on board?—Either by boxes or slings.

Is there a box always at hand?—Yes, one on each side.

What sort of accommodation is there on board for horses in the steam vessels?—The fore-hold will contain six horses.

What floor is there?—It is a wooden floor and it is battened; a horse would find his feet better upon ballast, but you cannot put ballast there, for if a horse was to kick some of the stones into the engine, it would spoil the engine.

How many sailing packets are kept in addition to the steam boats?—Two.

Do they sail every week?—No, they are changed monthly; there is the Chichester and the Pelham.

Supposing the sailing packets were to sail one from each side on particular days might not this give a better accommodation for the carriage of horses?—No; not will people go in them.

Is the *Ivanhoe* built sufficiently strong to stand the winter season at Holyhead?—She is not so strong as ours, but she is as strong as other vessels in general.

Is she strong enough to go through the regular service of the station at Holyhead?—While she is new she is; she would not run long.

Is she made of fir or oak?—Fir.

What precautions have been taken on board the *Meteor* and *Sovereign* to prevent accidents from fire in the arrangement of the furnaces and boilers?—There is water all round them, and they are kept three feet from the bottom, about fifteen inches from the side, and twelve inches from the deck; we are differently constructed from others, and it is quite impossible that any accident can happen; there is water under and on the sides of the fire places; in those boats that are fitted up upon the Clyde there is nothing but brick and mortar below the furnaces, we have iron;

Martis, 2^o die Aprilis, 1822.

Captain William Rogers again called in; and Examined.

*Captain
William Rogers.
(s. April.)*

IN the event of building a new steam packet, what improvements would you suggest in respect to the build, the engine, the sails, and to the interior arrangement of her?—I think I should build her in the same manner as the others are built, on Sir Robert Seppings's plan as to mode of fastening, diagonal fastening, &c. &c. only a little finer at each end, and one foot narrower than the Sovereign and Meteor, to be 95 feet in the keel, 105 or 106 upon deck, and 19 feet in the beam, about 180 tons, her transoms square, and not very high out of the water. The improvements in the engine would be to make them a little stronger, and the boilers a little longer, keeping them more from the side of the vessel, so that the heat might not affect her, and more room to go round them, and to put the boilers lower down.

What advantage would you get by putting them lower?—It would help to prevent their rolling. The Talbot's boilers are a little higher than the Ivanhoe; by putting the Ivanhoe's lower down, found she did not roll near as much. I would have the two main beams put close to the wheel, which will reduce the weight very much and strengthen and make the vessel much easier, as by being so far asunder adds great weight, and acts as a lever. There should be twelve paddles about seven feet long and nineteen to twenty-one inches wide. The engine should be something between sixty and eighty horse power, but this must depend upon the fineness of the vessel, and the water she will draw. If the engine is to be made much stronger, in that case we must not go further than two thirty horse power engines, as then the weight might be too much. I should recommend, with regard to the sails, a large lug forward, and a jib and a fore and aft mainsail; and in case any thing should happen to the engine, I would keep a square topsail on board, and a gaff topsail aft, but not to be used except in case of necessity.

You would also be able to set top-masts?—Yes.

Mr. James Brown called in; and Examined.

*Mr.
James Brown.*

You belong to the house of Boulton and Watt?—I have been agent for them some years.

Did you put up the engines on board the Meteor and Sovereign steam packets?—I superintended their erection.

What parts of the engines most frequently fail?—We generally consider the working parts, the cross bars, the side rods, and the side beams.

To what do you attribute the cross bars having broken on board these vessels?—In some instances from want of caution on the part of the engineer, and in other cases from stress of weather.

Were they made of cast iron or malleable iron?—Hitherto of cast iron; they are now made of wrought iron for sea vessels.

Have you put engines into any other vessels?—We have put engines into most of the vessels on the river Thames, the Dover station and Leith.

Have accidents happened frequently to those vessels?—Upon the Leith station one or two cross bars have broken, and that was entirely from want of caution on the part of the engineer in starting the engine; the other vessels were the Dasher and Arrow on the Dover station; there was one accident of a cross bar breaking in the Dasher.

Was that from want of caution?—I cannot say that.

Have accidents happened to vessels in the river?—In the first instance there were three or four little breakages, but subsequently they have gone on very well.

Has any other part of the engines of the Holyhead packets failed?—A shaft was broken, I think the crank shaft.

Was it made of cast iron?—Yes; and I believe its failure was attributed to there having been some screws drilled into the shaft to fasten on the risings for eccentric circles, it was considered that these wounded the shaft, as it broke up that part.

Have the side beams failed?—They are called side beams or main levers.

Have any of them failed?—Only one in the Meteor.

Is this made of cast metal?—Yes.

*Mr.
James Brown.*
(2 April.)

What would be the effect of making the whole engine as strong as possible, by using nothing but malleable iron?—I do not conceive you could make an engine without being liable to break; there are some parts so small that they must give way, and it is better the most insignificant parts should fail, than some of the principal ones, because they are easier repaired.

Is an engine liable to that extraordinary pressure upon it, under particular circumstances, that it is better to have some part that would give way?—I should think so; for instance, it would be better for the cross bar to break than the side beam, and if not either of those two, that some of the cutters or straps of the side rod should go.

You mean that it would be more easy to repair?—Yes; but if the engine-man sees any thing going wrong he has only to let off the steam.

Can those repairs be made at sea?—Not well; but there are generally duplicates on board of those parts liable to accident. You could not well straighten the bent parts of wrought iron at sea.

In case of constructing a new engine for a Holyhead packet, can you suggest any improvements?—Merely in respect to making the materials stronger and heavier. I conceive the construction of the engine is almost incapable of improvement as it now is.

Would you make any alteration in the arrangement of the boilers?—It would be better to lower the whole machinery together, bring the engines nearer the centre of the vessel, and let the boiler rest upon the keelson.

Would you require more room than was allowed in the *Sovereign* and *Meteor*?—Yes; it would be better we should get round the boilers entirely, they could then be painted every month, which would be a great advantage, for the action of the salt water is very detrimental to the iron; they ought to be painted every three weeks, or every month; where a boiler will not leak with fresh water it will with salt water; and it forms incrustation upon the surface by exposure to the atmosphere; they should be pumped out, and frequently cleaned.

How long would it take to paint a boiler?—Half a day.

What number of voyages may an engine go, supposing the distance to be each voyage twenty leagues, without looking over and making a thorough examination of it?—I should think the engineer generally looks over his engine every morning before he starts, to see that every part is properly oiled, and that every screw and joint is tight. If so inspected, once a fortnight would be sufficient to examine the packings of the slides and pistons.

Supposing the vessel to finish her voyage late in the evening, and go to sea again early in the morning, would it not be necessary to lay her by occasionally to examine her?—I think it would be an advantage to the service to have a spare vessel to perform the duty while repairs were being done to the others, and overhauling the machinery.

Would it not contribute to the preservation of the machinery to have that overhauling take place at particular periods after a certain number of voyages?—Certainly.

What time would it take to overhaul an engine completely, to ascertain whether it was in any respect injured?—If there were no repairs to do I should think two days would overhaul all the packings about it, even doing it leisurely; if exertion was required it might be done in half the time.

Would you make the paddles for a new engine different from those put to the Holyhead packets?—We should make them the same as for the Leith vessels, they are made with wooden floats in one piece, having three sets of arms, and the bolts are of a peculiar description, which allows the paddles to slip from the outer end of the arm towards the centre of the shaft, by which means a vessel may use her sails the same as any other vessel; should any thing give way, there would be nothing but the arms in the water.

What time would it take to get rid of the paddles?—There would be only four or five to get rid of; the four topmast paddles would be slackened, and fall towards the centre of each wheel, the wheels would thus be turned round, and the bare arms would be in the water.

How would you steady the wheels to enable the men to work upon the paddles?—By lashing the wheels fore and aft with tackles.

Have you not some contrivance for engines at work on shore, so that if they become exposed to any sudden violence, they stop themselves?—Pumping engines have.

Have you been able to apply the same principle to engines on board vessels?—

I do

I do not conceive that could be well done so as to act of itself; the engine-man should take the steam off, and disengage the eccentric, when he sees any accident likely to occur.

Is it not for want of some such precaution that many of the accidents have happened?—Perhaps in some cases it may be so, but I should apprehend it depended more upon the engineer than any thing else; he should never quit the engine room.

What circumstance is it that chiefly occasions that sort of excessive violence which contributes to injure and break the engine?—Any of the working parts getting loose, any of the screws getting between the finer parts, or the water getting upon the top of the piston in starting the engine.

In what way can the water get upon the top of the piston?—It is from the condensed steam that forms from the boilers after the passage is over, it gets through the steam pipe to the cylinder and condenses there, perhaps to the depth of 18 inches on the top of the piston, and if the engine is started suddenly without it being cleared away, it has not time to get through the thoroughfares.

What is the consequence?—The consequence is, that it is jammed between the top of the piston and the under side of the cylinder cover, and risks the breakage of some part; as water will not compress, something must give way, and the weaker parts of course will go first.

Is the City of Edinburgh steam vessel employed to go from London to Leith?—She went there during last season.

For what months?—I think on the 24th of June I first went with her.

When did she stop?—I cannot say positively, I think the beginning or middle of October.

Was she exposed to many gales of wind?—Her first passage was extremely rough, we were eighty-four hours making the passage.

What is the shortest time she made the passage in?—I think fifty-eight hours.

What is the distance?—We reckon it 450 miles, and I believe that is near it.

Do you take enough coal with you?—Yes, they have a sufficient supply in the coal boxes, and for a third of the passage more.

Why did she not continue to go through the winter?—I suppose she would not have paid, she is a large vessel of 400 tons.

Was she strong enough?—She was built at Blackwall yard, and that is quite enough to say she was sufficiently strong; the floor timbers were about 12 inches square.

What was her tonnage?—401 tons, the length upon deck 143 feet, and 14 feet depth in the hold.

Is she of a similar construction to the Holyhead packets?—She has not the diagonal timbers; she is built the same as other merchant vessels.

What precautions have been taken in the arrangement of the furnaces on board the Holyhead packets, to prevent accidents from fire?—I hardly think it is possible that fire can take place, because the furnaces are completely surrounded with five inches of water round every part, and it is only in raking out the fire, and neglecting to water it, that any accident can take place; it is raked out upon an iron floor.

No rolling of the vessel could throw the fire about?—No; she must be pitching to a great degree, if that was to take place.

How are the coals carried?—They are in boxes in front of the boilers, so as to be right and left for the fireman.

Are those boxes cased with iron?—They are made of iron entirely.

Can a body of water be let in from above, in case of an accident by fire from neglect?—No; but there is a hand pump in the engine room to be used when they are filling the boilers, and they can get water enough from that; in the new Leith packets we have put jet pipes, the same as fire engines have.

Could you put these jet pipes on board the Holyhead packets?—Nothing could be easier.

What are the precautions taken to prevent accidents from boilers bursting?

I can hardly conceive on board these vessels, where condensing engines are used, that it is possible that such a thing could take place; they are generally provided with two safety valves, and the steam used is about from two and a half to three pounds pressure upon a square inch, at which pressure it blows off by the safety valve of its own accord.

How are those safety valves arranged, so as to be at all times operative?—Boulton

Mr.
James Brown.
(c. April)

Mr.
James Brown.
(1 April.)

and Watt have made them for many years in the way they now are, inaccessible for any person to load them by putting additional weight upon them; I have seen the Scotch engine men, in starting their engines, place their feet upon the safety valve.

Suppose by any accident the safety valve was out of order, and the pressure became too great for the strength of the boiler, and it was to give way, what would be the effect on the boiler?—Supposing such a thing, which I conceive is impossible, that the safety valves should get choked, the steam would come off at the feed pipes.

It would not give way under any circumstance?—No, not even though the valves were choked, the pressure is so extremely small; the boilers are calculated to sustain fifty times the pressure required of them.

If any part of the boiler, by length of use, became very thin, and gave way, would it fly or rend?—Merely rend, if malleable iron.

Were not the accidents that happened from boilers, sometime ago, owing to their being made on the high pressure principle, and being made of cast iron?—Yes, they were.

When made of cast iron, and the pressure too high, they gave way, and the metal flew?—Yes, just like a shell.

Malleable iron tears and rends?—Yes.

Without flying and doing injury?—Yes.

Have Boulton and Watt made any improvement in their engine since the Holyhead packets were built last year?—Not that I am aware of, the principle remains the same as it was when it left the late Mr. Watt's hands; the construction of the engines has not varied since the Meteor and Sovereign were built; they have made them stronger and added malleable iron in parts where cast was used.

Those were the first vessels that had engines for the sea from Boulton and Watt?—Yes, they were, and they are the first vessels that ever ran all the winter.

What quantity of fuel do they consume?—I think the experiments made in the river with the Meteor showed that she consumed about seven bushels per hour, rather under, she was then working above her full speed; the Sovereign I think was from nine and a quarter to nine and a half; the Meteor has two thirty horse engines, and the Sovereign two forty horse engines; the latter when using that quantity of coal was going about nine miles and three quarters through the water per hour.

What time does this give for each ton of coal for the Meteor?—A bushel of good Newcastle coals is reckoned equal to a hundred weight of Scotch coal; so that it comes to very nearly the same thing; the Scotch coal generally burns very free and so does the Staffordshire, but the bushel of Newcastle coal is equal to a hundred weight of either.

Do you know the proportions of the Whitehaven coal to the Newcastle or Staffordshire?—No, I have no certain knowledge whereby I could speak of it.

What is the ordinary weight of the bushel of Newcastle coals?—The standard bushel should weigh eighty-eight pounds; the best Walls End, I have found them eighty; and the Wylam, seventy-seven; I found that by actual weight the specific gravity of the Wylam coal is much under that of the Walls End, the latter is not good for working engines.

What description of coals is the best for these engines?—The best coal we have been able to meet with is the Halbeath or Inverkeithing, from a place in Fife called Inverkeithing.

What is the peculiar quality of them?—Burning free and becoming a complete white ash without caking upon the fire bars.

Is it necessary to have a coal that ignites very quick?—Yes, if it does not cake afterwards. It is a great object to get good coals. In the first passage that I went with the City of Edinburgh from London to Leith, the coals were very indifferent, and we were obliged to clear the fire every four hours.

Did you take the fires out?—Yes, took them out one by one completely; in coming back we had a description of coal called Halbeath Main, and with them went sixteen hours without cleaning the grates; the sulphur in coals will destroy the fire bars in a short time.

Do you find any inconvenience from salt forming in the boilers?—Yes, when the main hole cover is taken off and they are exposed to the atmosphere, the water then becomes crystallized and renders them very difficult to clean.

Has this been avoided by any plan?—Yes, by constructing pumps or cocks to let the water through the side of the ship without the main hole being opened.

Does

Does that prevent the crystallization?—Yes, quite.

Has the salt water much effect upon the boilers?—It oxidates the iron very rapidly indeed, if it is allowed to lie upon it.

What period will a boiler last, supposing it constantly in use?—On board a steam vessel, I should think from four to five years with care; it is the only part of the machinery subject to decay.

These engines, upon the whole, require a considerable degree of care and superintendence, and skilful engineers?—They certainly do require more care than the land engines; every engine requires great care.

Captain John Percy called in; and Examined.

You command a steam packet on the river?—Yes, from London to Margate; the Hero.

Have you commanded any other vessel?—Yes, the Victory, belonging to the same company; I commanded the Victory for three years; the Hero was built last year.

Do you go through a good deal of sea occasionally?—Yes, off the Margate sands, when it is blowing from the northward and eastward on the top of the tide, she being such a large vessel, feels it more.

What is the tonnage of the Hero?—427 tons.

What is the power of her engine?—Two engines of fifty-horse power.

Who are the engines made by?—Murray and Fenton, of Leeds.

Where was the vessel built?—At Rochester.

What months in the year have you been running these vessels?—We begin about the latter end of April and run into October, about the middle of October; I have run into November in one year, the 14th of November.

What engines had you on board the Victory?—Two twenty-fives.

By whom made?—Mr. Dickson, of Holland-street, Blackfriars.

Are you acquainted with Boulton and Watt's engines?—We have not any one in our concern; I am acquainted with vessels that run with them, and I rather think they are the best; they have not had so many accidents as we have.

What sort of accidents do you allude to?—First, the cross-heads in the Hero went away twice in the last season, and several of the bolts and the steam pipe went; now we have got copper ones in the room of cast iron.

From your experience in conducting those vessels, can you suggest any improvement that can be made in them, in respect of the engine or the vessel?—In respect of the vessel, we should improve if we had but half the projection work; in consequence of their being such an immense hang over, it jars so, enough to shake the vessel to pieces.

In respect of the engine, can you suggest any improvement?—Not as to the engine; as to the boilers, we never find ours last more than two years.

What part gives way first?—The bottom.

What quantity of coal does the Hero consume an hour?—Pretty well three quarters of a chaldron or twenty-seven bushels, London measure, per hour; in general, they make away with six chaldron in the passage, that is owing to the want of flues; we have not flues enough; we have four furnaces; it is owing to an error in our burners, that we burn so many coals.

What is the distance from London to Margate?—About eighty-four miles.

At what rate do you commonly go?—We generally make the passage in about seven hours and a half, that is the average passage; one passage I made in six hours and sixteen minutes, with the wind and tide.

What sails do you carry?—Very handsome lugs, fore and main lug and jib, and a square sail when it will admit of it.

You have two masts?—Yes; we used to work them with mizens, but we found they carried so much weather helm, that they did more harm than good; most of our vessels want head sail, and not aft sail.

When in heavy seas, do you find the engines work well?—They jar a good deal when they pitch.

How wide are your paddles?—Eight feet in the centre.

How many paddles have you on a wheel?—We have been trying an experiment last Saturday with twelve, and it answered very well; last summer we worked with sixteen paddles, three and a half feet between each.

Have you ever used paddles wider than eight feet, in any vessel you have been

*Mr.
James Brown.*

(3 April.)

*Captain
John Percy.*

*Captain
John Percy.*

(8 April.)

aboard?—No; I believe the Hero is the widest of any vessel running; the paddle of the Victory was five and a half in one place; the Hero worked more with the paddles being further apart, and we lowered them a little.

How much have you lowered them?—The Hero was the fastest vessel on the river; we raised them seven and a half inches, and then we were the slowest; now we have raised them four inches, and that will be about the thing.

What made you raise them?—They thought the vessel would go faster and easier.

How much do they take of the water?—About seventeen or eighteen inches.

What does your engine work up to?—Thirty strokes per minute she did on Saturday.

What is the lowest?—Twenty-two; she once did up to thirty-one, but twenty-nine and thirty is about the go.

What is the diameter of your wheels?—Fourteen feet.

Have you ever commanded a steam vessel at sea?—I have been across to Calais when His Majesty went over.

How did she perform her voyage?—Pretty well going, it was fine weather; but she worked very much coming back, it was owing to the width hanging over; she jarred so much, you would have thought the top was coming from the bottom; if it was not for that, she would be the fastest vessel in the water.

How many feet water does she draw?—Six feet four. I have not a doubt had the hang over been taken off we should have done very well. The vessel I have to contend with draws only four feet eight; in smooth water she will do very well, but in sea-way she will not do, she rolls very much from want of depth of water to check her.

Where do you carry your coals?—Close to the fire, in two iron tanks, that hold six chaldron and a half; there is a little clap-hatch at the bottom where they keep working down; we carry two stokers.

What precautions have been used to prevent accidents from fire?—There is a set of buckets on board.

What is there under the furnaces between them and the ship's timbers?—Iron plates.

Is there nothing under the iron plates?—No, that is before the furnace mouth.

What is under the bed of the furnace?—Large, stout, heavy iron plates.

Is there no brickwork?—No, none; the greatest danger is in raking the rubbish out after the passage, and not cooling the ashes. She burns such an amazing quantity of coal, and that makes the heat the more, and damage has been done to the timbers from that.

Does your vessel go out every day?—No, there is a day between each passage, one in town and one at Margate, to examine and clean the vessel. We sail from London on the Saturday and come away from Margate on the Monday, and go down on the Wednesday.

You have a day's holiday between each passage?—Yes.

Do you find that time necessary to keep the vessel in order?—Yes; we find all the time taken up; the men are never still.

How many hours, on an average, does your passage require?—About seven and a half.

How many miles an hour does that make?—Between eleven and twelve.

Sabbati, 20^a die Aprilis, 1832.

Mr. Joshua Field, called in; and Examined.

DO you belong to the house of Messrs. Maudslay?—Yes.

Who are engineers?—Yes.

Have you constructed any engines for steam boats?—Yes, several.

What vessels were they?—The Richmond, the Regent, the Engineer, the Rising Star, the Earl of Egremont at Portsmouth, and several abroad; one is the Québec, five hundred tons, fifty-six horse power; another a large ferry boat: these engines were sent out; they are in the river Saint Lawrence; one to Hambrogh, the Duke of Cambridge, and one to China, to work between Canton and Macow.

Have any of the vessels you have mentioned been made use of for sea voyages?—^{Except in summer, to Margate, they have not been used for sea voyages.} I omitted

Mr. J. Field.

(20 April.)

to mention the *Sovereign*, a vessel lately built by us, expressly for sea navigation, between Dover and Boulogne.

How long has she been built?—She has just now commenced operation, within the last three weeks.

What is the power of her engine?—Two engines of sixteen horse.

What is her tonnage?—About a hundred tons.

Has she performed many voyages?—About six.

Has she been out in any rough weather?—Yes, very.

How has she answered?—Exceedingly well.

Have any parts of the machinery given way?—Nothing more than the paddle arms; that is the only thing which has given way.

Are the materials of the engine cast iron or malleable?—Both cast and wrought.

What is the main shaft?—That is cast.

What are the cross bars?—They are wrought.

What are the side beams?—They are cast; we have made shafts and beams of wrought iron in several instances.

Why have you put a cast iron shaft into this vessel?—Because the shaft was short, and might be sufficiently large to compensate the difference between the strength of cast and wrought iron.

Would you put a cast iron shaft with engines of sixty or eighty horse power?—If a shaft is made of dimensions sufficiently great, cast iron might be safely applied.

But would not those dimensions become inconvenient from the space they would take and the weight of them?—I do not imagine they would; the weight is certainly an objection.

Do you consider, upon the whole, that cast iron is preferable to wrought iron?—If wrought iron can be depended upon to be perfectly sound in all its parts, it is unquestionably the best; but I have seen several instances wherein wrought iron shafts have broken.

What is the difficulty of forming wrought iron shafts?—The same difficulty that exists in uniting all large masses of wrought iron so as to be perfectly sound in all its parts, besides the great expense.

Is the iron subject to be injured much by the forging and heat requisite for working it?—No, it is not subject to be injured when worked with judgment; but the carelessness of workmen will sometimes make an unsound shaft or crank, which it is very difficult to detect or guard against.

Is there any method of proving the soundness of a shaft of wrought iron before it is put into use?—It might be submitted to some proof, but it is difficult to submit it to exactly the same kind of strain it is to be subject to.

Could the proof, applied to iron chain cables, be applied to the shaft?—I think such proof might, but it would require an apparatus expressly for the purpose.

Does the engine you have got in the *Sovereign* differ in any respect from those you have put into other vessels in its principle?—Not materially.

Was it made stronger for the sea, than usually made?—Rather stronger, particularly about the shafts.

Have you had an opportunity of trying the *Sovereign* packet with the new post office packets on the Dover station?—Yes.

What has been the result?—The *Sovereign* and *Dasher* ran together last Friday, and the *Sovereign* beat the *Dasher* on the passage from Dover to Boulogne, and also beat her on the passage back on Saturday.

Does the regular post office packet go to Boulogne?—No; the captain took her to Boulogne on that day, we suppose rather to try her speed with the *Sovereign*.

Did the *Sovereign* beat her by much time?—I believe about eight or nine minutes, somewhere thereabout.

Where was the *Sovereign* built?—Built at Dover, by the proprietors.

Is she built in the same way as the steam vessels are built, for use on the Thames, or built stronger?—Stronger.

Stronger than merchant vessels, or common sailing packets usually are?—No; I should not say stronger than merchant vessels usually are; she is clinker built.

How many feet of water does she draw?—Six feet two.

What is the breadth of her beam?—Sixteen feet.

What sails does she carry?—She has a jib and foresail, a mainsail and a mizen, and a square sail used before the wind.

What is the breadth of her paddles?—Five feet.

Mr. J. Field.

(20 April.)

Are they made upon any particular construction?—No, they are made of iron curved.

Can you put the wheels out of gear?—Yes, we can.

How many paddle boards have you?—Eight.

What is the diameter of the wheel?—Nine feet.

What part of the engine do you commonly find first fails?—From wear or decay the boilers; but in the engine I do not know; it is perfectly accidental.

You have had accidents with engines, of course?—Yes.

And what do you consider to be the chief cause of accidents, generally speaking; is it the stress of weather or sea, or the neglect of the engineer?—Both; some accidents have arisen from the vessel being weak, and straining the machinery in a sea; some from neglect in feeding the boilers: those accidents that happened to the boilers have chiefly arisen from carelessness in feeding the boiler, or from want of sufficiently cleaning or changing the water.

Is not the engine exposed to accidents from not clearing the water from the top of the piston?—Accidents have happened, and in some cases we have applied a valve on the cylinder lid to prevent it.

Do you think that will prevent an accident of this kind?—Yes; completely.

Under all cases?—Yes.

You have tried it in engines at sea?—Yes; we have frequently observed a considerable discharge from it, which otherwise would be compressed in the cylinder.

If that valve had not been applied, probably some accident would have happened?—Yes; most likely.

Have you found it completely answer to protect the engine from this species of injury?—Completely.

Have you made any engines of very large power for vessels?—Seventy horse power.

What vessel has that on board?—The Engineer has an engine of seventy horse power.

Do you find she has superior speed in consequence, and upon the whole is a superior vessel in point of power?—The tonnage of her is so great that the proportion between power and resistance is not so great in her as in some other vessels.

What is her tonnage?—Three hundred and fifteen tons.

Suppose you had to provide an engine for a vessel of two hundred tons to perform sea voyages, and built with the greatest possible degree of strength, what power of engine would you put on board her?—If the object was to contend with violent winds and sea I should put as much power as the vessel would conveniently carry.

To be used on the sea and to go through the winter navigation, as for instance between Holyhead and Howth, where it is subject to great gales of wind and violent tides?—Steam boats have been built with a view to afford great accommodation to passengers, therefore the space allotted for the engine has been limited; but a vessel built expressly to carry the mail across a tempestuous sea I should imagine that nearly the whole vessel might be appropriated to the machinery.

Would you always make the power in proportion to the space you had for the engine?—It would be more advantageous to do so.

It is your opinion the greater power the better the vessel will be?—Yes, in all cases; no vessel ever had a sufficient power yet.

Are there no circumstances with respect to the weight and space which a large engine takes up, which would counteract the utility and advantage of it with regard to its power?—There is a limit, but that limit has never yet reached its fullest extent.

Suppose in a vessel of two hundred tons merely to carry mails, without any consideration of passengers, what engine would you say would be preferable to put into such a vessel?—Without determining upon the plan, it would be difficult to state the power that could be put in; but I should think in a vessel of two hundred tons two fifty horse engines might be very well placed in it, making one hundred horse power or even more.

Does the weight of the engine increase much in proportion to the increase of power?—It does not increase in direct proportion.

Could you use paddles sufficiently wide to have the full benefit of so large a power, in a vessel entirely for performing sea voyages?—I do not see any reason why.

What breadth of wheel would you propose for two fifty horse engines?—They should be eight or nine feet wide.

That

That would be a sufficient width to give the vessel the full benefit of the power?

Mr. J. Field.

—Yes.

How many paddles would you put into a wheel?—Experience has pointed out a proportion, which is generally one to every foot of diameter, or thereabouts.

(20 April)

Then what diameter would you make a wheel for such a vessel and with such an engine?—About fifteen feet.

Could not two fifty horse power be placed in a vessel of 200 tons, and still leave room for thirty or forty passengers?—I think it could.

How many feet of the length of the vessel would such an engine require, including the boiler and all the apparatus?—I am speaking rather at a guess now, but it would be about forty feet.

In what part of the vessel with respect to the centre would you place the engines?—Rather before the centre; the centre of buoyancy of the vessel.

Where would you place the boiler?—Rather behind the centre of buoyancy.

And where the axle of the wheel or shaft?—The most forward part of the engine.

In what position would you place the boiler with respect to the water line of the vessel?—There we cannot do as we would; the general rule is to keep the centre of gravity of the whole as low as possible; we cannot place it lower or higher as we would; the object is to keep it as low as possible.

Are the boilers commonly placed above that line or below it?—They are below it.

Could not the boilers be so adapted by giving them greater length as to get them lower than they are usually put in steam vessels?—They may a little, but not much; I am speaking of the centre of gravity of the boilers; the bottom of the boilers should be placed as low as possible.

How low could the bottom of the boilers be placed over the keelson of a vessel?—If the boiler is formed to the shape of the vessel's bottom it may be brought down nearly on the keelson; the boiler is so formed in the Sovereign.

Would this contribute to lower the centre of gravity of the boiler?—It would contribute to that.

What sized boiler would you propose for two fifty horse engines?—That is a question which, to answer without calculation, is rather difficult; about twenty cubic feet to a horse power.

Is that the rule on which you make your boilers?—Yes.

Do you think it is necessary to have so large a boiler from the experience you have had with engines?—I think so; certainly.

What method have you of getting the water out of the boilers after a voyage?—We let it run through the side to the level of the water on the outside, and then a pump throws out the remainder.

Are you able to clear it without letting in the atmospheric air?—It may be thrown out by the force of the steam, and is in some cases; otherwise the atmospheric air must be admitted.

Do you find any inconvenience in your engines by the formation of salt in the boilers after voyages?—Yes.

Have you contrived any remedy for that inconvenience?—Nothing; excepting changing the water very frequently, and affording the greatest facility for that purpose to the engine keeper.

What precautions are taken in the vessels in which you have put engines, to prevent accidents from fire?—By insulating every part in which the fire acts from the vessel by water, and that for some way up the chimney.

You mean the furnace also?—Yes.

How is the platform arranged so as to prevent the fire in the furnaces getting into contact with the timber of the vessel?—The fire places are sufficiently below the deck or wood-work of the vessel to prevent any communication with the deck; and the floor is plated with iron.

Is there any other substance between this iron and the timber?—No; the radiant heat from the ash hole is not great enough to fire the timbers of the floor when well plated with iron.

Might not this iron get so hot as to communicate to the timbers below?—I should not think it is possible by mere radiation from the under side of the bars.

In case of accident, what means have you for obtaining a supply of water to put out fire?—In some cases we have an engine with a hose and branch pipe on board to apply to any part of the vessel.

Mr. J. Field.

(30 April.)

Where is that engine to work?—On deck.

What other arrangements have you of obtaining water on a sudden for the purpose of extinguishing fire?—We have had no other than a common pump on deck for the ship's use.

Have you had accidents from fire on board any of those vessels in which you have been concerned?—About six years ago a vessel caught fire and was consumed; it had not water round the chimney.

What vessel was that?—The Regent.

Was it on the Thames?—It was on its voyage from London to Margate; the fire was discovered under the deck over the boiler.

Is it necessary to have a good deal of room about the boiler in order to clean it?—It is advantageous to have a passage round it.

How often do they require painting?—Once in three months would be sufficient, I should imagine, but of course the oftener the better.

Is it necessary to examine the vessel very closely after each voyage?—Certainly it would.

To what extent should an examination of that kind go?—Particularly to see that the boiler is well cleaned, and that all the parts of the engine are in perfect order.

Would it be necessary to examine the packings, the slides, and piston?—I include that in the latter part of my answer.

How many voyages might a vessel go without any other examination, except the cursory examination that might take place in the interval between the two voyages?—That depends very much upon the quality of the engine; some engines would not go so long as others, without thoroughly being examined and tightening all their parts.

In order to give the engine a complete examination and to go over all its parts, so as to take care that every thing is right, what time would be necessary?—One day in a week at least.

Is a day sufficient to go over the whole?—At least a day.

Would there be much of the engine to undo?—No, not a great deal.

What quantity of fuel is burnt on board the *Engineer* by the hour?—I think on an experiment at which Mr. Donkin was present, I think it was somewhere about seven and a half bushels.

At what would you estimate the weight of the bushel?—Eighty-four pounds.

What coals did you make use of?—I think they were Wylam coal.

Does the new vessel, the *Sovereign*, you have mentioned, roll much at sea?—Very little; the centre of gravity being kept down as much as possible.

It has been generally an objection to the steam vessels that they roll a good deal at sea?—Yes; it has arisen from that cause.

Are you of opinion that an engine should be so constructed as to calculate upon some part of it breaking in case of a very great degree of pressure upon it?—If that part can be very speedily repaired there might be advantage in having a weak place.

But upon the whole, would it not be better to make an engine of the greatest possible strength so as to avoid breakages?—Certainly.

What would then be the consequence of an increased pressure upon it when an ordinary engine would give way?—It would stop.

And the steam go off by the safety valve?—The effect in that respect would be the same as stopping the engine in the ordinary way.

From your experience in constructing engines for river navigation and for sea navigation, would you make the engines much stronger for the sea than for use on a river?—I should make them stronger for both a river and for the sea, and particularly for the sea.

Then you think in no case they have hitherto been made sufficiently strong?—I think not.

Does the experience you have had in engines enable you to suggest any other alterations in the general formation of them?—I am not immediately aware of any other.

Are you making any other engine at present for any vessel?—No; we are not at present.

If you were making a new one, would you make that different from the one you put last on board the *Sovereign*?—No.

Captain Rogers, again called in; and Examined.

It appears from the return of the post office that the average length of voyage of the Royal Sovereign, from Holyhead to Howth, is seven hours and thirty-six minutes, and that the average length of voyage of the Meteor, from Holyhead to Howth, is eight hours and thirteen minutes; and also that the average length of the voyage of the Sovereign from Howth to Holyhead is six hours and fifty-seven minutes, and the average length of voyage of the Meteor, from Howth to Holyhead, is seven hours and four minutes; is not the difference of the voyage to be attributed to the different power of the engines?—Certainly.

Captain Rogers.

(20 April.)

In building a new packet, why then should not the power of the engine be at least eighty horse power?—In the way they are making the engine it would be very heavy; it would be more weight than the last, and we should require to have a much larger vessel, and that will do away with the power of the engine.

Do you think a vessel of 400 tons would bear an engine of eighty horse power, made with the degree of strength that it ought to have?—It must depend upon the width of the hold; but that will make the vessel very high, and the draught of water considerable.

With a vessel of the dimensions which you proposed, when last before the Committee, could not a steam engine, with an eighty horse power, be put into such a vessel?—No; unless the best part of the works was allowed to come upon the deck.

Then your reason for not proposing an eighty horse power for such a vessel, is merely the room which it will require, and its great weight?—Yes; I think we shall make a vessel with two thirty-fives, and fit a proper vessel for the Holyhead station, to go in any weather, and beat the present vessels on the station there.

Is there much additional expense incurred by increasing the engine's power?—No, very little.

Is there a great additional consumption of fuel?—Very little; we should require much larger wheels and broader paddles; by putting proper wheels for the two thirty-fives we should be able to make a sailing vessel as well as a steamer without any inconvenience.

What breadth of wheels?—About six and a half feet to seven feet; we are going to make this vessel very snug.

When you were last before the Committee you mentioned that you found inconvenience from the rolling of the steam vessels at Holyhead, have you reason to suppose in building a new one that inconvenience can be avoided?—Certainly, a great part of it.

By what means?—By narrowing the vessel, we are too stiff at present.

Will a vessel of that description be equally fit for bad weather and heavy seas?—Yes.

Have you heard in what manner the packets have gone across the Channel in the late easterly winds?—They were detained once or twice by a rough and very heavy gale; they could not sail.

Did it blow heavy at Holyhead from the east?—It blew very heavy from the east.

For what time?—I cannot say exactly, because I was not there, about a week.

Are those the first gales from the east that have been at Holyhead this year?—Yes, certainly, this year.

Did the steam packets make their voyages during this blowing weather?—One day they were detained at Howth.

Was not the Meteor a long time making her passage?—I do not know how many hours, but it was very bad weather, so bad, that the Liverpool steam packet could not come out, which shows the superiority of our vessels.

What number of small boats do you carry?—We carry one.

What number of people would that small boat contain?—We might crowd eighteen or twenty into it.

What number of passengers do you carry usually in one of your vessels from Holyhead to Howth?—Eighteen or twenty.

And what number do your crew consist of, independent of your passengers?—Fourteen or fifteen.

Making thirty in all?—Yes.

Therefore in case of any accident between Holyhead and Howth, you are not provided

Captain Rogers.
(20 April.)

provided with sufficient means, especially if it were to happen in the night, to save yourselves and passengers?—We seldom go off at night; I do not think we could carry boats to save the whole.

Are you not aware that the steam packets for the purpose of carrying passengers generally from Liverpool, do take a much greater number of passengers than you mention?—From two to three hundred in one vessel.

If an accident were to happen in one of those boats at any considerable distance from shore, from fire or other cause, are they provided with any means for the purpose of saving the lives of the people on board?—No.

Are you of opinion that it would be possible for those vessels to carry such an increased number of boats on their quarters, or on deck, in such a manner as they might be stowed, without much inconvenience, as would be competent to carry and to save the lives of the passengers?—No; we could in our own, we can carry two.

Can you not carry one over each quarter?—We can carry two, but all that is lumber; we never think of being drowned or burnt now.

Are you not aware that the Liverpool steam boat called the Robert Bruce, took fire off the coast of Anglesea in the last autumn, when only a few miles off the shore, and ran with difficulty on the beach and saved the lives?—We are differently constructed from them; they placed all their coals on the top of the boiler, or the best part of them, which occasioned that ship to catch fire; we are very differently fitted up to what they were; that vessel caught fire in consequence of the coal being on the top, and the water got low.

Is it the practice in the vessels employed to carry passengers from Liverpool to the Clyde, and from the Clyde to Ireland, to be constructed in the same manner as the Robert Bruce was?—Yes; I believe it is.

Do you not think there is a great risk in so fitting out?—I do.

Then if those vessels were provided with all the precautionary means which are on board the packets employed in the post office service, would they not be enabled to save the passengers in case of fire?—I do not see how they could carry boats to save so great a number.

Is not the deck of the vessel of great width in proportion to the tonnage of the vessel?—Yes.

Supposing a steam boat measures 300 tons, register tonnage, what proportion would the deck bear to a ship of 800 tons?—Full as large as a ship of 800 tons.

Does not the extension of deck afford the means for stowing and carrying small boats with greater convenience than if there was less deck room?—Certainly; they could carry boats that way.

Might not a steam boat carry boats in the proportion of eight or ten tons to each 100 registered?—I think that would be attended with very great inconvenience; they might carry one over the stern and one over each quarter, and one on the midships.

Might those four boats be so constructed as to contain 150 people?—I am afraid not.

What number might such boats contain in your judgment?—About 120.

Would it not be prudent in your judgment that the legislature should provide that steam boats, in proportion to their tonnage, should carry a certain proportion of small or row boats, where employed for the purposes of carrying passengers only, and at a certain distance from land?—I think that would be a very good thing.

Mr. Timothy Brown, Engineer, called in; and Examined.

Mr. T. Brown.

You are acquainted with the properties and principles of the steam engine?—Yes, and in a general way with the principle of a steam boat.

What is your opinion with regard to the strength that may be given to an engine so as to prevent accidents?—I should prefer that the engine and machinery connected with it should be made of sufficient strength to provide for its being stopped by any accidental resistance, which should require its ultimate power; in other words, that it might be brought to rest without the fracture of any of its parts.

Have you had any experience of engines so strong as to meet with extraordinary resistance and still not give way?—One instance has come within my own personal observation, and another instance I have known some years since, from the best authenticated testimony, which was in a rolling-mill, where the rollers were supplied for the express purpose of ascertaining the strength of every part, and the engine was brought up without any accident. The other instance of my own observation

was,

was, in a grinding-mill, where the machinery was instantaneously brought to rest without any accident to the engine or machinery.

Mr. T. Brown.
(20 April.)

Under what circumstances?—Owing to a sudden resisting medium; which equalled the momentum of the whole machine, occasioned by a piece of wrought iron getting between the stones.

Then you would propose that engines should always be made sufficiently strong to bear the greatest resistance?—Yes, but I do not mean to say, that they can with propriety be made so strong, that if the extremity of the paddle wheels came in contact with a hard substance they would not break; I mean to say that the machinery should be strong enough to resist the utmost effort of the engines without the fracture of any of its parts, in case of its being stopped by the sudden accumulation of water on one or both of the paddle wheels.

Have you had any experience with respect to the size of the boiler per horse-power?—I have seen the boilers of a boat engine something less than sixteen cubic feet per horse power, and they have been made as large as twenty-eight feet per horse. I should think, according to the ordinary mode of construction, that twenty cubical feet per horse power would be sufficient for large engines; but I am of opinion, that a very great improvement may be made in the boilers of boat engines, where it is so very material to diminish the weight of the apparatus; I mean by diminishing the cubical contents of the boiler without lessening the superficial surface exposed to the action of the fire; as the quantity of steam evaporated in a given time, depends upon the surface exposed, and not upon the quantity of water contained in the boiler; the object of lessening it, in a great degree, appears to me clearly practicable; and I am very much confirmed in this opinion from an experiment I have lately witnessed in our own works.

Are you able from any experience you have had from the use of steam engines on board vessels, to give an opinion as to the quantity of power best suited to the object of making a vessel go with rapidity through water, and successfully through a heavy sea?—The more power that can be provided within the limits of the vessel, the greater the effect will be, and you cannot have too much power; indeed it is always of advantage to have as much power as can be obtained.

Does the weight of the engine increase in proportion to its power, very considerably?—It does increase; but I am not prepared to state in what ratio.

Can you say the difference of weight between two sixty horse power and two eighty horse power?—It is a matter of calculation; it is less than a direct proportion.

Supposing in a vessel of two hundred tons?—I should think that the additional weights of twenty horse power would not make a very material difference; and that the advantages of such increased power would be very great.

Then in constructing an engine for a vessel to be employed at sea, and throughout the winter, you would give such a vessel the greatest power that her size would conveniently admit of?—Yes.

Is an engine much more likely to go out of order from its power being very much increased?—No; I should think not.

So that the engines of two fifty horse power are not more likely to be out of repair than two of thirty?—I conceive not.

Then, except with respect to the space, you know of no reason against using the largest power?—None.

Suppose it was found by experience on sea voyages, to be desirable to reduce the breadth of the wheel to the greatest degree practicable; is it not on that account desirable to make use of an engine of the greatest possible power?—Yes, certainly.

In proportion as you diminish the wheel you ought to endeavour to give greater velocity to it?—Yes, certainly.

In constructing an engine, would you on all occasions use malleable iron in preference to cast iron for sea voyages, in every part of it?—Great part of it, certainly; there are some parts which cannot consistently be made with cast iron, as the piston rods and others.

Would you make the main shaft of cast iron or malleable iron?—Of cast iron, I think, unless very long.

Are you aware that several of the cast iron shafts have broken?—Yes; I have seen one or two instances.

Can the cast iron shafts be made as strong as the malleable iron?—I am hardly prepared to say; I have seen many instances of malleable iron of large dimensions very imperfect, in consequence of overheating; I should think there would be a difficulty in getting the shafts of a large size so perfect as the cast;

Mr. T. Boswell.

(10 April.)

though it is a desideratum to adopt wrought iron shafts, as such shafts would yield the same strength with much less weight of material than those of cast iron.

Cannot those difficulties be overcome?—I think they might, by the possession of adequate means for their construction.

Then the defect of the shafts of malleable iron may be considered as owing to the imperfection in the construction?—Yes; I conceive so.

Is there any way by which you could prove the strength and fitness of a shaft of malleable iron to a steam vessel?—Yes; by subjecting it to tension, as in the case of chain cables.

Could this proof be applied by altering the proving engine to so large a mass of iron, as a shaft to an engine?—Yes, certainly; I have submitted a wrought iron shaft of seven inches diameter to a proving machine; and also one of four inches, which was broken; this machine was made for the express purpose of proving cables.

Was that shaft of four inches diameter a well formed shaft, or broken in consequence of an imperfection?—It was made to try the power of the proving engine, and in the section of fracture the iron was of very good quality.

What power did it take to break the four inch rod?—I cannot say at present; it is three or four years since: I believe we have a memorandum of it, but a bar of good wrought iron, inch square, will resist about twenty tons.

With such a proving machine might not a defect in common workmanship be easily discovered in a shaft of malleable iron?—A defect arising from the welding, the machine I have mentioned, would discover, but it only subjects the iron to tension.

But still it would ascertain in a great measure the perfection of the shaft?—Yes, in respect to its tension.

It goes to prove it is of sound material?—Yes, and adapted to its purposes.

Would it be expensive to construct a proving engine for ascertaining the quality of shafts made of malleable iron, supposing them of sufficient diameter for engines of sixty or eighty horse power?—A machine might be constructed of more universal application than the cable machine, so as to prove the shafts, not only in the direction of their lengths, but also to give them a transverse strain, exactly similar to that which is exercised on their application to the engine, and of sufficient force to prove the shafts of eighty or a hundred horse power engines. The expense of such a machine will be 600*l.* or thereabouts, but the cost will depend upon the length of it, and many other circumstances.

Do you consider a valve in the top of the cylinder to let off the condensed water a matter of importance?—Yes, I do; I have known one instance in which the beam of an engine was broken in consequence of the condensed water collected in the cylinder; by the introduction of this valve the accident would have been prevented.

Mercurij, 24^a die Aprilis, 1822.

Mr. James Brown, again called in; and Examined.

Mr. J. Brown.

(14 April.)

IN a vessel of 200 tons burthen, what sort of engine would you make use of with respect to power, in order to meet the resistance of sea navigation?—That would depend greatly upon the draught of water, the draught increases the resistance; for a vessel of about 200 tons, I should think from two five-and-thirties to two forties.

On what draught of water do you form your opinion?—About eight feet to eight feet six.

Are you aware that the average of the voyages of the *Sovereign* have been shorter by one hour than the average of the voyages of the *Meteor*?—No, I am not aware of that; but I should conceive it was owing to the increase of power.

Do you form your opinion about the power from your experience of the rate at which steam vessels have gone in smooth water?—From having been on board them at sea; I do not form my estimate from river navigation.

What is the greatest rate per hour at which a vessel has gone in still water?—The *James Watt* steam vessel is the fastest we know of, her speed is ten miles an hour through still water, independent of tide or wind.

Do you consider that the maximum of the rate?—It is hardly possible to say.

Would it require a greater increase of power to add to that?—The power required to double the velocity is as the cube nearly.

Do

Mr. J. Brown.

(24 April.)

Do you find that the speed of vessels can be increased above a very fast rate merely by increasing the power?—It is hardly possible to say that, because in some cases you might overload the vessel with the weight of the machinery and not propel her more than by a small engine; it is hardly possible to say what improvement might be made in speed; they have gone on increasing in velocity for the last two years.

Does not it stand to reason that in endeavouring to carry a steam vessel against a very heavy head sea you cannot have too much power?—I would certainly have a reserve of power; in fine weather you need not use it if not necessary.

Would not two engines of fifty horse power be better on board a vessel of 200 tons than two of forty?—Yes if you can bring the draught of water to suit, but I am afraid it would overburthen a vessel of that size.

Your opinion is, you should have the greatest possible power that will not contribute to increase the draught of water too much?—Yes, certainly; I should think the power on board the *Sovereign* was a very proportionate power for that station.

Could you put a greater power on board the *Sovereign* without bringing her down in the water?—I do not know how it would affect her, nor do I recollect the build of that vessel; I am not aware that a little additional power would make much difference; I believe at Holyhead you are confined for water as well as at Howth.

Supposing the effect of putting two engines of fifty horse power into a vessel of two hundred tons was not to require a greater draught of water than eight feet, and supposing that as much space in the vessel would be given up to the engine as was requisite, without consideration of the accommodation of passengers, would it not be better for the purpose of resisting heavy seas, to have two engines of fifty horse power than two engines of forty horse power?—No doubt of it.

What is the additional weight of the whole apparatus belonging to two fifties over that of two forties?—I think the weight of two forties would be as nearly as possible one hundred tons complete with duplicates, and I should think from twenty to twenty-five tons more for two fifties.

Do you include in that calculation the weight of water, coals, and every other appendage?—Yes, every thing complete.

Would two engines of fifty horse power be more liable to get out of order than two engines of less?—Not the least.

Would they require a much wider wheel?—Yes, they would, certainly, to absorb the power.

What breadth of wheel would be necessary for two fifties?—The least one could give them, would be nine feet; they ought to have more.

Do you form your opinion upon a vessel going in smooth water, or in a heavy sea?—In the sea; the *Sovereign* has two wheels of eight feet each.

What is the size of the boiler on board the *Sovereign*, as to the horse power of the engine, how many cubic feet?—I cannot possibly answer that question; I believe it is about fifteen feet long, and at one part fifteen feet wide; I do not think that the cubical content of the boiler has any thing to do with the horse power.

What depth of water is commonly kept up in the boiler?—That depends entirely upon the size of the flues and the power required.

Are you aware that a great difference of opinion prevails among engineers as to the cubical contents of the boilers, in proportion to the power of the engine?—Every engine maker has his own rule as to the size of the boiler.

Do you consider this part of the subject in any way settled?—No; every one has his own mode of constructing boilers; the generality of these, I believe, carry the smallest quantity of water possible.

As the great space that is required for an engine on board a vessel, forms one of the principal inconveniences, is it not desirable to reduce the cubical contents of the boiler as much as possible?—No doubt of it.

Might not this be done by maintaining the same superficial surface, and diminishing the actual depth of water in the boiler?—That would depend entirely upon the space you give in length for the boilers; because what you have not in length you must have in breadth.

Are the cubical contents of Mr. Watt's boilers, generally speaking, less than the cubical contents of other boilers?—I really cannot say; I have not given any attention to other boilers.

Was the expense of the engine on board the *Sovereign* much greater than that on board the *Meteor*?—I think about 1,000*l*.

Mr. J. Brown.

(24 April.)

What would be the expense of two engines of fifty horse power above the expense of two engines of forty horse power?—I think the two fifty horse power would be about six or seven thousand pounds, and the two forties would be about five to six thousand pounds; when you come to the difference of five horse power, the expense is very little more.

Is there not a method of supplying furnaces and engines with fuel by machinery?—There is.

Describe it to the Committee.—There is one adopted by Mr. Brunton, which is the best I have seen, which is a revolving fire-place, connected with the engine by means of a certain apparatus attached to it, by which the coals are let gradually into the fire as it turns round.

Does this method of keeping up the fires diminish the power of the engine?—I am not aware that it does.

Does it tend to save fuel?—I have heard that it does; but I am not aware how that has been ascertained.

Do you think this machinery could be applied to engines on board sea vessels?—I am afraid it would render it very complex, or if it would answer the purpose, when done.

Would it take up considerably more room?—Unquestionably.

Does not it diminish the quantity of heat coming from the furnace in the places contiguous to it?—I have no experience to enable me to say that it does not.

Sir Edward Lees, called in; and Examined.

*Sir
Edward Lees.*

WHAT has been the general effect of the establishment of steam packets at Holyhead, on the arrival of English correspondence in Dublin?—A very considerable proportion of the mails have been delivered on the second day to the public in perfect time to answer the letters the same night. We have had the mails from England as early as half past two o'clock in the forenoon, at the post office; and the hour of delivery in Dublin is as late as six o'clock in the evening by the letter carriers.

Are all the letters that arrive before six delivered?—Yes; they are delivered that evening, all that arrive before six.

Have the mails arrived in many instances later than the second evening from London, when brought by the steam packets?—Up to the month of December (I am speaking from recollection,) I had particular occasion to examine at that period as to the effect; from the month of June, when the packets commenced, up to December, there were but twenty-six mails that were not in time to be forwarded from Dublin by the mail coaches that evening, a period of seven months; and that including several days while His Majesty was at Holyhead, when the mails did not go by the steam packets, but in the regular packets.

Before the steam packets were made use of, what was the usual arrival of the London mail in Dublin?—Comparatively the number was scarcely worth mentioning that arrived on the second day as early as four or five o'clock in the evening; I now consider the mail due in Dublin at three o'clock the second day, which we never did before till six o'clock the following morning. In 1805, when I first came over to England, before the arrangements were made as to the mails arriving at Holyhead, the number was not sixty in the year, which got over on the third morning for delivery; and I do not think twenty in the year reached London on the third day from Ireland.

If the London mails could be brought to Holyhead by half past four in the morning, at what time ought they to arrive at the post office in Dublin with the present average voyages of the steam packets?—It might be there in eight hours, or eight and a half; that would be one o'clock.

How long does it take to make a delivery of English letters after their arrival in Dublin?—I think the letters should be out of the post office on delivery within two hours.

At what time could persons have letters at the alphabet office after the arrival of the mail?—It is quite possible to give them in an hour and ten minutes.

So that the arrival of the London mail so early in the day would enable the merchants and traders of Dublin, to receive their English letters long before

the hours of business were over?—They could receive them before the hour of change, three o'clock.

At present they only receive them, generally speaking, after the regular hour of change?—Yes; after their dinner hour; generally after their counting-houses are closed.

At what time does the office shut up for the receipt of English letters?—The public receiver is kept open till ten o'clock at night; the letters for which postage is paid, are excluded at seven; the interior parts are shut up at seven.

Then if the mail arrived so much earlier in Dublin it would be perfectly easy for men in business to write answers to their letters the same day that they receive them?—Certainly.

Be so good as to state to the Committee the various regulations adopted by the post office in Dublin for accelerating the dispatch of the conveyance and delivery of English letters?—I think we have carried into effect nearly every thing the Committee of 1819 recommended; I think that embraces the earlier delivery of the letters in Dublin, and the dispatch of the English letters both from Dublin and the interior, on Sundays; it also recommended the discontinuance of the practice of fees on the landing of passengers at Howth; it suggested a more extended delivery of letters from England through Dublin; and also a similar advantage through the alphabet. Those several suggestions have been acted on; the hour of delivery by letter carriers has been extended from five to six o'clock P.M.; and any mail that arrives so late as half after seven P.M. is delivered from the alphabet. The Committee also recommended, that the same principle of mail coach and rate of travelling should be observed in Ireland as in England.

Have any letters been sent from the interior for England on Sundays?—Regularly; on such lines as mail coaches exist upon.

Are letters sent from the interior of Ireland from any post offices for England on Sundays that are not on the mail coach line?—No; I do not think there are.

What is the reason of this exemption?—Because the post office pays but for the conveyance of six days in the week on the cross posts; and if you obliged the riding-masters to convey on the seventh day, they would make an increased charge; at the same time there are several lines of country upon which the mails might be conveyed upon the seventh day on which I do not think the post-masters could have any legitimate right of claiming that additional remuneration.

Would not the postage on letters sent on Sunday on those lines pay the additional expense thus charged for the rides?—Probably they might pay something; but the letters that did not go on the Sunday would go on the following day.

Does not your experience show you, that the greater number of days you afford for letters being written, the greater number of letters are written?—Most certainly.

Is it intended to make any alteration in the arrangement for allowing English letters to be sent on Sundays from the interior of Ireland?—Immediately previous to my leaving Dublin it was submitted to the government and approved of, with a view of saving the expense of the seventh day, that on some roads the mail should no longer come to Dublin on the Sundays from the interior.

Did not the public derive great convenience from the adoption of the recommendation of the Committee of 1819, in allowing letters to be sent from the interior of Ireland so as to go to England by the Sunday's packets?—Letters came from every line of road in Ireland on the Sundays.

Does not the regulation that prevents letters being put into the post office upon Saturday deprive the interior of the means of corresponding with London for two days in each week, in consequence of no letters being delivered in London on Sunday?—Exactly; the same arrangement which would deprive from receiving the English mails on the Sunday in Dublin from the interior of Ireland, excepting on the lines that the contracts existed for the seventh day, would also have the effect of preventing their dispatch from Dublin.

Will the packets continue to go on the Sundays?—Yes.

What was the reason for withdrawing the regulation so recently made for sending English letters throughout the interior of Ireland on the Sunday night, and allowing them to be sent from the interior on Saturday night?—Merely to save the expense of the carriage, which was at the rate of one pound per mile per annum: to Cork, for instance, it is 126*l.* per year. The prohibition does not extend to more than two or three roads.

What is the gross amount that will be saved by this plan?—Precisely one pound

Sir Edward Lear.

(24 April.)

per mile per annum; I do not recollect the exact amount; I think not more than 250 *l.* a year, or 350 *l.*
Have you the order for stopping the transmission of English letters on Sundays?—
No, I have not it here.

*Lancæ, 29th die Aprilis, 1822.**Mr. Bryan Denkin, called in; and Examined.**Mr. B. Denkin.*

(29 April.)

YOU are, I believe, a professional engineer?—I am.
Are you much acquainted with steam engines?—I understand steam engines.
Have you turned your attention to engines used on board vessels?—I have been employed professionally to examine several of them.

What is your opinion with respect to the quantity of power that should be given to an engine on board a steam vessel?—From the observations I have made in most of the vessels, I have found them to have too little power for the size of the vessels.

Do you speak with respect to vessels used in rivers or at sea?—I have been chiefly acquainted with vessels used on the river Thames; I have seen others, but I am not so intimately acquainted with them as I am with those upon the river Thames; I have no further acquaintance with them, as sea boats, than having passed on several occasions from Margate to the Nore.

Is it not more desirable to secure a sufficiency of power for the purposes of sea navigation than even for the river navigation?—I should think it highly desirable in either case.

Upon what rule has the quantity of power been regulated for vessels used in the river?—I believe we can scarcely say that any specific rule has been adopted as yet; we may even now consider that steam boats are in some degree in their infancy; but the conclusion that I have come to is, that it appears to be necessary that one horse's power should be employed for every two feet, and about three or four-tenths in the transverse sectional area of the vessel, to give the vessel a velocity of eight miles an hour through the water; I was first informed of this by Mr. Field, who has already been examined before this Committee, and I have confirmed it by subsequent observations upon other vessels; that is the only rule with which I am acquainted; if a greater velocity is required in the vessel, a greater power must be employed.

Then you take eight miles an hour as the maximum speed?—I take that merely as a standard, the general rule with regard to all vessels passing through the water is that the power to impel them must be as the square of the velocity, or very nearly so; there is a little difference probably, arising from the various shapes of which vessels are made, but the general law may be taken as true.

After having made use of sufficient power to impel a vessel through the water at the rate of nine or ten miles an hour, does not the quantity of power increase in a great ratio, which would be requisite to give an additional speed of one two or three miles more per hour?—To double the velocity you must have quadruple the power.

Does that practically answer?—I have tried it in several instances, and I have found it correct; sufficiently so for any practical purpose.

The power which is applied to vessels is, generally speaking, with a view of securing the rate of about eight or ten miles an hour, is it not?—It is, from eight to nine; I believe, independently of the wind, that ten miles per hour is a velocity seldom arrived at.

To secure the same rate of speed at sea, and in vessels navigating through the winter, and at all seasons, and in all weather, ought not the scale of power to be considerably increased?—With reference to the average power that has been employed, I think it would require to be nearly twice as much; we may consider the steam vessels under three different states; that is, going with a favourable wind, when there is no wind at all, and with an adverse wind; if the vessel and the steam engine be so constructed as to have the velocity required in its passage from one port to another, in still weather, the consequence would be, that there would be too much power for a favourable wind, and too little power for an adverse wind; therefore, I should recommend, that the steam engines be made considerably larger than necessary for giving it the velocity in still weather.

Do you consider it very desirable that the greatest strength for the size should be given to engines on board sea vessels?—Most undoubtedly.

What

What are the reasons that particularly lead you to form that opinion?—From having seen accidents in several steam boats, and various parts of the engines broken.

Do you think, as yet, engines for sea vessels have been made too slight?—Many of them have; I believe there are very few of them but what have had accidents; one great cause I believe of those accidents, has been the making many of the parts of cast iron which ought to have been made of wrought iron.

You would, therefore, in constructing an engine for a sea vessel, make use of the greatest power and the greatest strength that the room in the vessel would allow of?—Unquestionably I would.

Is there any practical inconvenience arising from increasing the power and strength of an engine?—None whatever, that I know of; excepting the expense and the room it occupies; but to counterbalance that, there is an advantage in not being obliged at all times to work the steam engine up to the extent of its power; supposing a hundred horse engine to be employed in doing the work of fifty horses, the quantity of coals consumed when so employed, would be less than in the proportion of the power; that is, it would be less than one half what it would be if the engine was performing a hundred horses work.

Is the engine more likely to want repair in consequence of its increased power?—Less likely; if it is not wrought up to its full power.

Does the weight of an engine increase very much in proportion to its increased power?—Not in proportion to its power.

Does the expense of making one increase in proportion to its power?—No; not after they get to a certain size; they are less then in the proportion of the power.

Is it not necessary to have the breadth of wheel in proportion to the power of the engine?—Yes it is; the breadth of wheel must be in proportion to the power of the engine.

Is it found by experience that the breadth of the wheel forms a difficulty in sea navigation?—I do not know what it may do at sea; but in the river Thames, where the crowded state of the pool exposes the widest vessel to the most danger in passing and being passed by a number of barges and other vessels constantly in motion, it is very dangerous.

What is the rule for regulating the breadth of the wheels in steam vessels?—I do not know of any precise rule; the resistance of the water against the paddles depends upon their depth in the water, as well as upon the width of the wheel; I have found, on comparing the wheels of different vessels, that the sectional area of that part of the wheel immersed in the water varied; but that about three-tenths of a foot might be taken as the quantity allowed for every horse's power.

Then it is upon this principle the breadth of wheel is now regulated?—Yes, I conceive so.

Have any improvements been made in the paddles of wheels?—No; I do not know of any, excepting that of making the arms of wrought iron, so as to lessen the weight; paddles have been made of a variety of shapes, but I believe it is immaterial what shape they are, provided the area or surface exposed to the sea be sufficient.

Has any method been invented for getting the paddles off the wheels so as to give the vessel the advantage of the sails in case the engine gets out of order?—I think, if they had proper fastenings there would be no difficulty in getting them off, or taking them up out of the water, very easily at any time.

In what way do the fastenings make a difficulty?—By long exposure to sea water the bolts become rusted, and sometimes break before they can be got out; bolts and nuts in such a situation are frequently so firmly united by rust as to require the bolt to be cut before it can be taken out.

What sort of boilers do you recommend as the best for steam engines at sea?—I would recommend boilers such as have been introduced into some of our best steam vessels, in which the fire is completely insulated by surrounding the whole of the fire-place and flues with water, and thereby securing the vessel against any accident by fire. It is my opinion, that in by far the greater number of vessels hitherto made, the capacity of the boilers and the quantity of water they contain are much too large; and that the fire-places and the surface of flues exposed to the fire and heated air are too small. By doing so, the vessels have been loaded with a useless weight of many tons, and the engines have been inadequately supplied with steam.

What is the right proportion between the contents of the boiler and the power of

Mr. B. Denon.

(29 April.)

of the engine?—In some instances I have known it in the proportion of twenty cubic feet to one horse's power; that I think far too much. I believe that the quantity of water in a steam boiler for any boat need not be more than eight cubic feet of water per horse.

Will that size give steam sufficiently fast for the engine?—The quantity of steam supplied does not at all depend upon the quantity of water; it depends entirely upon the size of the fire, and the quantity of surface exposed to the action of the fire, provided there be but a sufficient quantity of water to cover the flues. I think the superficial area of the fire should not be much less than one foot to a horse, and the area of the whole surface exposed to the action of the fire need not be more than from ten to twelve superficial feet for every horse's power.

Have any boilers been made upon this plan that you are acquainted with?—The boilers which were originally made for the London Engineer steam packet, approach nearest to that principle of any that I have seen.

What is the proportion of the contents of her boilers to the power of her engine?—I do not exactly recollect; the superficies of the fire was sixty-three feet, that was rather less than one foot to every horse power; and it was the examination of that engine that induced me to recommend one foot to every horse power, because in order to keep up a good supply of steam they were obliged to put on coals very frequently.

Have you got the contents of the boiler?—The cubic contents of the water in the Engineer's boilers were 478 feet.

How many horse power?—They were working to the power of seventy horses.

What proportion does that make?—It makes nearly seven cubic feet to a horse.

That is a little under what you stated; you stated eight?—Yes; and it answered the purpose very well, and it need not be more than what I have stated.

How did those boilers answer?—They answer better than any boilers I have ever seen on board a steam packet.

Was there much attention requisite to keep the steam going?—Yes; there was great attention required to keep the steam up, because the quantity of fire-place was not sufficient; I think the fire-place ought to have been larger; the proportion is as sixty-three to seventy.

The proportion of what?—Of the superficies of the fire to the power of the engine; that is, there were sixty-three feet of fire employed to raise steam for seventy horses power.

Did it require great attention to keep the boilers properly supplied with hot water?—Not more than the ordinary attention required in steam boats, where the boilers are fed by hand.

Are not steam engines on land supplied by their own machinery with water?—They are supplied by a self-acting apparatus.

That is by a float?—By a float in the boiler, acting on a valve, which admits and shuts off the water as the water becomes lower or higher in the boiler.

Has the same principle been applied to boilers at sea?—I have not known one.

Then at sea the water is supplied by the attention of the persons who attend to the engine?—By the attention of the men.

What were the boilers made of on board the Engineer?—They were made of copper originally.

Do you conceive copper to be a better material than iron for making boilers?—I should prefer it decidedly.

What are the reasons that induce you to give it the preference?—Because the copper may be made thinner, consequently lighter, and it is much more durable.

Is it so much exposed to injury from the salt water?—No.

Can you obtain the steam faster in a copper boiler than in an iron one?—Yes.

Is it much more expensive?—Yes, I apprehend it would be considerably more expensive; I believe we can get a good wrought iron boiler at the rate of 38s. or 40s. a hundred weight, and a copper boiler, I suppose, would cost from 14d. to 16d. per pound.

What is the common thickness of a wrought iron boiler?—The thickness varies considerably; I have known them one quarter of an inch, and I have known them half an inch.

What is the usual thickness?—If the boiler is not very large, I think three-eighths is quite sufficient.

For what sized engine?—For very large engines from two to three boilers are generally used; therefore the size of the engine makes but little difference.

What

What is the common thickness of a copper boiler?—Three-eighths of an inch for the bottom, and one-fourth of an inch for the sides and top.

Is there *not* this advantage in using copper boilers, that after the boiler is worn out the old material is worth nearly as much as the original price of the boiler?—Yes; whereas wrought iron is worth very little or nothing.

Is less fuel necessary for a copper boiler than an iron one?—Yes; I should think there is a saving in the fuel.

What is the weight of boilers of wrought iron for two engines of forty horse power?—About eighteen tons.

What is the weight of boilers made of copper for similar engines?—About fifteen tons. Were the boilers of the Engineer steam packet altered?—They were altered.

In what way?—They were made of wrought iron.

Can you state the reasons for altering them?—I believe the proprietors were induced to do so, under an idea that they would generate more steam, if made much larger than the copper boilers; they were put in and did much worse than the former ones.

Had any thing occurred to induce the owners of this vessel to put aside the use of the copper boilers?—I believe the chief reason was, that the vessel did not go quite so fast as one or two other vessels from London to Margate; and they thought that if they had more steam the engines would be more powerful, and perhaps come up to the velocity of other vessels; they were altered with a view to increase the quantity of steam. The copper boilers had been at work two seasons, and to all appearance as good as when first put in.

Did they increase the cubical contents of the boiler?—They did.

In any considerable degree?—The cubic contents were nearly doubled.

What was the effect of this alteration upon the speed of the Engineer?—The effect was that the vessel went much worse than she did before; they had lessened the fire-places and had increased the quantity of water in the boiler; the weight of the boiler was increased likewise, so that altogether, I believe she drew from four to five inches more water than she did at first; the weight of the boilers was, I believe, thirty-three tons, and they contained about eighteen or twenty tons of water.

Then by altering the boilers for the purpose of giving them a greater proportion of cubical contents to the power, they did not succeed in their object of getting more speed?—No, they got less.

Are you acquainted with any other steam vessels that have copper boilers?—No; I have not seen any; I believe they have been generally objected to on account of the expense.

You believe that is the only objection?—I believe so.

In case the engineer omits to supply the boiler with water, is not a copper boiler more liable to be injured by the fire?—No; less liable, I think.

What is the effect of negligence in supplying sufficient water?—The effect is that the water becomes expended, and the bottom of the boiler being unprotected by any water upon it, is heated red hot, the plates become softened, and the expansion of the steam generally forces them down towards the fire.

Are land engines now supplied with fuel by machinery without the aid of workmen?—There is a new apparatus recently introduced to several engines near London, for the purpose of lessening the consumption of fuel and supplying itself.

Is it found to answer?—Extremely well.

Is the consumption of fuel much lessened by this apparatus?—It is found to combine the two advantages of burning the smoke, and of lessening the quantity of fuel consumed.

Are you of opinion that this apparatus may be applied to engines on board ships?—Yes, I think with very great advantage; it probably would require a little variation in its construction.

What are the general advantages of this plan?—The general advantages are economy of fuel and labour, and greater safety to vessels.

In what way do you consider that it would contribute to greater safety?—Because it would prevent the continual operation of feeding the fire by hand, which requires the fire doors to be open every five or ten minutes, and the frequent stirring of the fire occasions a great deal of the ignited coals to fall through the grate and upon the floor, whereas, in this apparatus the coals are supplied by the machine itself; the fire doors need never be opened excepting about twice or three times a day.

What becomes of the ashes in this plan?—They fall immediately from the grate upon a cast-iron plate; but the quantity of ashes made is very small; I suppose a hundred horse engine would not make five bushels in a day.

Mr. B. Davkin.

(29 April.)

Is there not a great loss occasioned by the constant raking of the fire?—A very great loss; I have made some experiments lately as to the consumption of fuel in the ordinary mode of feeding the fire by hand, and by the use of this apparatus, and we have found, with perhaps one of the best constructed furnaces of the kind, that the new apparatus produced a saving of twenty-five per cent. of fuel.

On board steam vessels is it not frequently necessary to take off the fire altogether to clear the grates?—That depends very much upon the kind of coal that is used.

Is it not sometimes necessary to clear the fires as often as every four hours?—It is; and with some coals, much oftener.

Would this trouble and labour and delay be all saved by the use of the apparatus you have just mentioned?—In the engines I have mentioned they only find it necessary to stop twice a day to clinker the fire.

Is it necessary to stop the course of the vessel to take off the fire?—No, they do not stop altogether; but it impedes the vessel by lessening the supply of steam.

Not for any length of time?—No; they do it to one fire at a time, but the operation is frequent, and they are obliged to have the door open when they do it, and a current of cold air rushes in and cools the boiler.

Does the fire produced by this apparatus work more regularly and powerfully than the fires supplied in the ordinary way?—Yes it does; small portions of coals are introduced upon the rotary fire place at certain intervals, so that the fire is regularly supplied; the combustion goes on entirely at the surface, and the incombustible matter, such as the vitrified parts of the coal, and the ashes, settle down upon the bars, and protect them from the action of the fire.

You have not stated the influence of the fire in producing steam, and its heat?—There is a greater quantity of radiant heat and flame given out in the direction in which it is wanted, namely, upon the bottom of the boiler; in ordinary fires, supplied by hand, a great quantity of the heat is lost downwards upon the ash-pit; I believe that, together with the exclusion of the cold air, are the chief causes in producing a saving of fuel. Comparing this method with the old one, less than half the size of the fire-place will answer the purpose.

It produces steam quick, does it not?—That depends upon the supply required; there is a mode of regulating the quantity of coal supplied at each interval, so that if you have a regular demand for steam you can give a corresponding supply of coal.

Would the operation of this machine be affected by the rolling of the vessel in a heavy sea?—Not more than a common fire.

By whom was this apparatus invented?—A Mr. Brunton, who has a patent for it.

Is it coming into general use?—I know of several; I think the first was introduced at Messrs. Liptrap's distillery; I there saw two of them at work, one applied to a steam engine, and the other applied to a very large still.

Has it ever been tried on board ship?—Not to my knowledge; I believe not.

Could it be readily affixed to any other person's engine, not made by the inventor?—Yes; any engine.

How long has the patent been taken out?—I should imagine the patent must have been taken out about three years; between two and three years. The same apparatus has been applied to an engine at Chelsea, belonging to the Grand Junction Waterworks Company.

Does this apparatus consume its own smoke?—Nearly so; I have seen them working with that engine, which is of a hundred horse power, for an hour together, and there has not been as much smoke as arises from a common kitchen fire.

Veneris, 3^a die Maji, 1822.

Mr. Bryan Donkin, again called in; and Examined.

(3 May.)

UPON what principle is the machinery in a steam vessel arranged?—I believe the principle is to place the centre of gravity of the whole mass of machinery, with the load of water, and so on, nearly in the middle of the vessel. There has always been a difficulty in the arrangement of the machinery to get it low enough. Most of the steam vessels with which I am acquainted have been made with flat bottoms, and the consequence is that the weight of the machinery raises the centre of gravity of the vessel too high, and the vessel becomes very liable to roll.

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Do you know how the centre of gravity of the vessel with the machinery in it bears with respect to the water-line?—The adjustment ought to take place between the centre of gravity of the vessel and the centre of buoyancy. The centre of gravity of the vessel and its contents ought to be below the centre of buoyancy; or if the centre of gravity were to be placed above the centre of buoyancy, the vessel would then overturn; and the nearer they approach each other, the vessel will be more subject to roll; the lower it is, the steadier it will be in the water.

Has the centre of gravity, in any instance, to your knowledge, been above the centre of flotation?—No; I do not know that it has.

Does it approach anywhere near?—I have been on board some of the flat-bottomed vessels, where I have observed the position of the vessel to be considerably altered by a few of the passengers changing their places from one side to another, consequently the two centres must have been very near each other. But although this circumstance renders a flat-bottomed vessel very unsteady in the water to a certain extent, yet she is prevented from going over altogether, because the figure of the transverse section of the fluid displaced is continually changing with every change of position of the vessel, so as that the centre of buoyancy is removed from the middle of the vessel nearer to the side to which the vessel inclines, and thus the vessel is thrown back again towards the contrary side.

What contributes principally to prevent a steam vessel in a heavy sea from going over?—This, in every case, will depend upon the relative positions of the centre of gravity and the centre of buoyancy, and the force of the sea to which the vessel is exposed. If, as in flat-bottomed vessels, the centre of buoyancy is removed to a greater distance from the centre of gravity, or as in vessels where the transverse section is of such a figure as to admit of the centre of gravity being placed considerably below the centre of buoyancy, the vessel will not turn over so long as the force of buoyancy on one side shall exceed the force of the wind and sea on the other. A steam vessel for sea should be keel-built, which would give an opportunity of placing the machinery, boilers, &c. and, consequently, the centre of gravity, much lower than can be done in a flat-bottomed vessel.

Would the tendency of the weight in such a case be to prevent the vessel going over?—Certainly; the centre of buoyancy would be considerably above the centre of gravity.

Then the weight would be continually contributing to place her in an upright direction, like ballast in a sailing vessel?—Yes; the weight of the machinery, &c. would supply the place of so much ballast.

Has any improvement been made recently in respect to the arrangement of the machinery on board sea-vessels?—I have seen a plan, which I am of opinion will be an improvement of some consequence; but as I was confidentially consulted upon it, I hope the Committee will see the propriety of my not explaining it here. With the general principles of the invention I may make the Committee acquainted. The advantages of such an arrangement will be the simplification of the machinery of the steam engines; the opportunity it would give of introducing longer cylinders, thereby giving a longer stroke to the engine, and superseding the necessity of employing cog-wheels, as has frequently been done for the purpose of lessening the number of revolutions of the impelling wheels, computed with the number of strokes of the engines; and it would render the engine much more independent of the strength of the vessel to which it might be applied, and less liable to accidents. Mr. Brunel, of Chelsea, is the author of this invention.

What is the difference practically in the height of cylinders for engines used on land and cylinders used for engines at sea?—I should think nearly one half less at sea than on land.

Then in that proportion the engines at sea work to a disadvantage?—Not in that proportion; for in consequence of being shorter, and the pistons moving slower, they are made a little larger in diameter; but there is a considerable disadvantage in it, both as to the consumption of fuel and the working of the engine; as in the latter it requires more frequent alternations of the beam, the piston, and the valves, which occasion more wear upon the parts than where the cylinders are made longer.

Have you heard of any improvements in other parts of the machinery being in contemplation?—I have heard of several projects, but I believe none of them to be effective. I have heard of none which I consider as essential improvements but the one I have mentioned.

Is not there considerable difficulty in keeping the boiler clean?—Yes.

Mr. B. Doak.

(3 May)

From what cause?—The deposition of salt.

What methods are taken to prevent the deposition of salt?—I know of only two methods. In the Regent steam boat they employed a method very successfully, and that of pumping the hot water through the boiler, and allowing a certain quantity constantly to be discharged from it into the sea; by these means the water was always kept in a sufficiently diluted state, so as to prevent it becoming saturated with salt, and consequently none could be deposited.

Is this process going on while the boiler is at work giving steam?—Yes, constantly going on.

Does it produce no inconvenient effect upon the steaming power?—No otherwise than by requiring a greater consumption of fuel. The boiler is supplied by the hot water drawn out from the engine by the air-pump, and introduced into the boiler generally at a temperature of 90° or 100°, so that whatever was the surplus quantity of boiling water thrown out, that quantity would be lost, and the consumption of fuel would be increased. The other mode is the common and ordinary one of taking out the whole of the water when they arrive at the place of destination, and putting in fresh, and if there is any deposit of salt, taking that out also.

How is it taken out?—They have doors or apertures near the bottom of the boiler, which can be opened or closed at pleasure for that purpose.

Will there always be a certain deposit of salt after a voyage?—The only answer I can give to that question is, that if the passage is of such duration as to allow the water to become saturated with salt, there naturally will be a deposition of salt after saturation has taken place.

With every care taken to prevent it?—There will be, unless the water is continually diluted in the way I have mentioned in the first instance. I believe it to be the safest mode.

Have you met with instances of any inconvenience arising from neglecting to take out the water after voyages?—Yes, I have; where the inconvenience was such as that one of the boilers generated very little steam; there were three boilers in one vessel, and one of them produced very little steam. We ascertained that by its requiring very little water to be introduced into it from London to Margate; therefore we know it could not have the effect it ought to have in generating steam.

What is your opinion with respect to making use of cast iron in the machinery of sea-vessels?—My opinion is, that every thing which by possibility could be made of wrought iron ought to be so made.

Would you make each part of the greatest possible strength?—I would make every part of a steam engine for sea-service at least of three times the strength of that which by estimation would be required to resist the power of the engine when in its ordinary state of working, in order that they might effectually resist the violent shocks to which they must necessarily be exposed in a gale of wind and a heavy sea. Accidents are most likely to happen at a time when the suspension of the power of the engine would be the most fatal.

That is, whatever the force of the engine was, you would make the various parts equal to three times that force?—At least three times.

You would not then make any part with a view of giving way in case of any particular pressure upon it?—Certainly not.

What would be the effect of an engine made as you describe, in case it was stopped by any excessive pressure?—The engine having been made strong enough to resist the greatest force to which by probability it might be exposed, such a force being brought against it the engine would stop without any harm ensuing.

What would be the effect of the re-action upon the boiler?—Just the same as when the engine was stopped for any other purpose, as frequently happens in the river, to take in passengers; the effect of that is, that the steam is not taken off by the engine; its expansive power or force increases so as to open the safety-valve, and it blows up the tube, and goes to waste.

Have you seen engines come to a stop in this way without any inconvenience?—Never at sea.

Have you seen it at land?—At land I have.

Will you mention an instance?—I attended an experiment some time ago with Mr. Field, who has paid great attention to the subject of steam boats. The experiment was upon a small engine, but the various parts of the engine being made in proportion to the power, it amounts to the same thing; and in trying the experiments we two or three times brought the engine up very rapidly, and nothing happened.

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The steam went off by the valve?—Yes; there is always a provision made for that purpose.

Is there any difficulty in making large shafts of wrought-iron?—There is with some people; but if a sufficient price be offered for them there is no difficulty in procuring them.

Then in your opinion all defects in wrought iron shafts may be completely guarded against by a proper selection of material, and a proper attention to the construction of them?—Yes; I think so; I object to cast iron in every instance where heavy consequences are depending upon their breaking, because I have seen many instances where cast-iron shafts have broken repeatedly, and in lieu of which wrought-iron shafts have afterwards been put in, considerably smaller in their dimensions, and of less weight; and I have not known one instance of their breaking.

May not the quality of the shafts and other parts of the machinery be submitted to a proof previous to their being made use of?—Yes, undoubtedly; but an effectual and satisfactory proof of shafts, applied to this purpose, would require a machine which would try the strength of a shaft by twisting it.

To what sort of strain are the different parts of the machinery exposed?—The shafts are exposed to a force in a twisting direction; the connecting-rods, and the links, and the piston-rods, are exposed to a strain in the direction of the length.

Does not the security of the machinery very much depend upon the constant care and skill of the individual engineer who happens to be in the management of it?—Certainly it does.

By what sort of neglect is the engine exposed to be broken?—By suffering the bearings upon which the shafts work, and the links connecting the piston with the beam, to get loose, and in some cases making them too tight, so as the bearings heat, and by not attending carefully to the adjustment of the steam-valve when the vessel is exposed to a heavy sea.

Is not very great care necessary in starting an engine that there should be no water upon the top of the piston?—Yes; either care should be taken that the water deposits itself in some other receptacle, or if it accumulates there, that it may make its escape without breaking any part of the engine.

Does water form there after a voyage from the condensation of the steam?—It frequently forms there after stopping the engine. There are two remedies for that inconvenience, one which would go nearly to prevent it altogether, and the other to prevent any mischief accruing if the water should be deposited upon the piston. There ought to be a valve immediately over the boiler in the steam-pipe, which would prevent the steam from coming into that part of the steam pipe, from which the condensed water would run into the cylinder. Whenever the engine is stopped, no steam ought to be permitted to come into the pipe of communication. The other mode is that which was suggested by Mr. Field, and which has been successfully applied: it is that of fixing a valve on the top of the cylinder, which allows the water to be forced through it, and prevents the danger which otherwise might arise from its accumulation.

Then you consider this valve as adequate to its object in preventing mischief to the machinery?—If it be made large enough, I should think an engine with such a valve would be perfectly secure.

What description of persons are commonly employed as engineers on board steam vessels?—Men who are called engineers; a set of men accustomed to attend engines; some of them engine-makers; and in my opinion no man ought to be employed on board steam boats as a superintendent, or to have the care of an engine, but one who perfectly understands the nature and construction of an engine.

Are they commonly working men?—Yes, working men.

Do the owners of steam vessels on the river, or in other places, where you are acquainted, place any sort of inspection over the managing engineer?—I know of one instance where a superior kind of inspection was aimed at, but I think it is discontinued now; I believe the steam-engine-makers are resorted to when anything happens to the engine. The inspection rests upon the proprietors, who generally have one man at least, in each vessel, as an engineer of superior skill.

Is it customary for the proprietors themselves to inspect the engines?—They generally have an inspecting manager, or a committee of management; but I have reason to believe that some of the steam boat companies have suffered severely from a want of regular professional inspection.

Would it not contribute to the safety of the engines and of the vessels, if occasional inspections

(Mr. B. Dwyer.)

(3 May.)

inspections were made by scientific and regular engineers?—I am of opinion that it would be found highly advantageous.

Have you been employed yourself to inspect steam engines used in vessels?—Occasionally I have inspected many on the river Thames.

Have you discovered on those occasions much neglect on the part of the engineers?—In some instances I have.

Should particular care be taken with respect to the coals used?—I think the coals ought to be particularly attended to; first, the kind of coals, and secondly, to avoid taking small coals, so long as the common fire-places are used; small coals occasion great waste; and all coals employed for steam boats ought to be screened.

In your opinion, what is the best quality of coal for steam engines?—We find on land in and near London, the Wylam coals are preferred for steam engines.

What is the peculiar property of this coal?—They produce less slag, or clinker, and turn more to ashes than most of the Newcastle coal. I think great care ought to be taken how, or in what state, coals are deposited on board a steam boat, for I believe several accidents have happened at sea (and I know they have on land) from their having been taken in wet, and laid in a warm place; the warmth accelerates the decomposition of the pyritic matter; and where coals are laid in a large heap under such circumstances, and the pyrites are very abundant, the coals take fire spontaneously.

Then you are decidedly of opinion that coals ought always to be put on board in a dry state?—Yes, I should recommend it.

Are all coals liable to this generation of heat by being put together in a damp state, and afterwards exposed to heat?—I cannot say all coals, but all Newcastle coal contains a greater or less quantity of pyrites, and are liable to do so.

Have you known any instances where Newcastle coals have taken fire in this way?—I have known one instance where a heap of coals took fire which were lying near the boiler of an engine, for which I could account in no other way.

Was the engine to which you now are alluding on land?—On land.

Does it require a very large mass of coals to produce this spontaneous combustion?—That I do not know; I have not any satisfactory experience of it.

Have any instances come to your knowledge of boilers on board vessels having burst?—I have heard of several boilers bursting, but have only seen one of them.

In your opinion, what was the cause of so many boilers bursting?—I saw one at Norwich after the accident had happened, and that had arisen from employing high-pressure steam. The boiler was a composition of wrought and cast iron, very injudiciously made; that part which was made of cast iron burst. There was another instance which occurred, I believe, two or three years ago, on the Thames. I did not see it myself, but I believe it was occasioned by the boiler having been badly made.

Are the boilers now usually made of wrought, or cast iron?—I believe of wrought iron universally for steam boats, excepting they are made of copper.

Do you recommend boilers to be made of copper?—Yes; I recommend copper, it will last ten times longer than iron boilers. I believe, taking iron boilers in general, they will not last more than two or three years.

Are high-pressure engines used now?—I believe they are not in this country. I understand they are used in America; but I have no certain knowledge further than report. But I am informed they make the boilers very different for high-pressure engines to what they do for the low-pressure engines; they are made circular, of a very small diameter, and of considerable length; the plates are of much greater strength than the ordinary wrought iron boilers.

Suppose a wrought iron boiler to give way, does it fly, or is it rent?—I never knew but of one instance of a wrought iron boiler flying; and I could only account for it in this way: it was a common shaped boiler, with a bottom convex upwards; the boiler was used for the purpose of generating steam of forty pounds per square inch, and employed for evaporating sea-water to procure salt. I believe the boiler had been suffered to become dry, or nearly so, and in that state the last portions of water would occupy the lowest parts around or on each side of the bottom of the boiler; the crown of the bottom would be exposed to the action of the fire after the water had been evaporated from it, and the plates of the bottom becoming red-hot, and therefore more pliant, would, from the expansive force of the steam, become flat, or driven downwards; upon which the remaining water round the sides flowed *converging* upon the hot plates; thus a large quantity of steam would be suddenly generated. The top of the boiler was completely rent from the bottom, and projected through the roof of the house to a considerable distance.

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In the instance you mention, you state that the boiler was employed to generate steam at the rate of forty pounds to a square inch on a high pressure; how many pounds to a square inch are employed in the engines on board the steam vessels?—From two to four pounds; there need not be more.

Do you conceive that boilers at the rate of two pounds to four pounds per square inch are in any degree exposed to accident?—I believe they are perfectly safe.

What would be the effect if a wrought iron boiler, from weakness of any of its parts, or from any other cause, were to burst?—Merely a leak in the boiler.

Would the materials of the boiler fly into pieces?—No; I apprehend it is quite impossible.

Then the whole inconvenience from the bursting of a wrought iron boiler, in a general way, at this low pressure, would be merely a rent in the boiler, and a leak?—Nothing more.

Is it difficult to repair an injury of this kind done to a cast iron boiler?—So difficult that it is scarcely ever attempted.

Are boilers made of copper equally free from being liable to bursting as boilers made of wrought iron?—Equally, if not more so.

What would be the effect upon the copper, in case of a part of it yielding to the force of steam?—Precisely the same effect as I have already described. It would occasion a leak, by which the steam or water would escape.

To what cause do you attribute that the same effect was not produced in the high-pressure engine you spoke of?—To the cause I have already stated, namely, the sudden generation of a large quantity of steam under a very high pressure.

Could that take place in the steam engines used on board vessels?—No; I do not think it is possible. From the construction of the bottom the water has always a tendency to settle to that part of the boiler where there is no fire, so that there could be no sudden flowing of the water over that part of the bottom of the boiler which might by accident become red-hot.

Would it not be better to have fresh water than salt water for the boiler?—Most undoubtedly.

Might not a sufficient quantity of fresh water be carried on board a steam packet to supply the boiler?—I think it possible to carry water sufficient to supply the boiler alone, but that it would be very inexpedient to do so.

Suppose the boiler were filled, in the first instance, with fresh water at the port of departure, might not sufficient fresh water be carried to supply the wants of the steam during a voyage of six or eight hours?—No, I should think not.

What is the consumption of water in two engines of forty-horse power per hour?—About forty-five cwt.

Since salt water is so injurious to the boiler, would it not be at all times right to fill the boilers in the first instance with fresh water before the vessel went to sea?—It would lessen the inconvenience, certainly; sea-water is objectionable with regard to steam engines from two causes, first, its action upon iron boilers, if they are used, and secondly, the deposition of salt. In the use of copper boilers, the first objection does not hold, because sea-water has very little action upon copper.

Are you acquainted with the passage from Holyhead to Howth?—No.

The distance being fifty-six miles, and the sea exposed to very severe gales and strong tides, supposing a packet sailed every morning from Howth, and another from Holyhead, throughout the year, how many vessels, in your opinion, ought to be made use of to perform this service, that they may go to sea in the best possible state, and with the machinery in perfect condition?—I think, with our present experience upon steam boats, I should be unwilling to risk less than four.

What are the reasons that induce you to think there ought to be that number?—In order that proper attention might be paid to the engines, the state of the boilers, and every thing upon which the safety of the vessels depends; and in case of accidents to one vessel, always to have another at each port ready to go to sea.

Would you propose that each vessel should lie-by a day after its passage, or sail a certain number of days together, and then lie-by for a general examination?—That ought to be regulated by what must result from experience; that is, by ascertaining at what period, whether in one, two, or more passages, the water became saturated so as to deposit salt.

Then as soon as you found a deposition of salt beginning, you would think it necessary to stop the vessel one day, to clear the boiler properly?—Whenever the water became saturated at the boiling temperature, it ought to be changed, but that might

M^r. B. Donkin.

(3 May.)

be effected without stopping a day, provided another set of hands was employed for that purpose, and set to work immediately after the vessel is moored.

Is it not essential that the whole engine should occasionally become cool?—On some occasions it is; but there is an advantage in keeping a steam engine at work as long as possible, because if it is suffered to get cool, the same degree of heat must be restored to the water and every part of the engine.

Would you be rather in favour of the same vessel performing a certain number of voyages before it stops?—Yes, as many as possible; but the only inducement to do so would be the lessening the quantity of fuel consumed.

How would you ascertain whether the water was depositing salt?—By ascertaining the specific gravity of the water in the boiler, or by drawing out a little water from the bottom of the boiler.

How often would you do this?—At the end of every passage.

Do you think it very essential to ascertain the specific gravity of the water after every voyage?—I do think it essential, until it is satisfactorily ascertained how long a boiler will work before the salt is deposited.

Have you, in the course of your experience, discovered inconveniences in consequence of neglecting it?—I have; in the Margate boats.

Is there much to do in giving the machinery a complete examination?—That would very much depend upon the state in which the engine, &c. might be found at each examination. But I think the closest examination might be given in a day.

Would there be any parts of the machinery to open or to undo?—Yes; it would frequently happen so.

But this examination, you think, could be effected in one day?—Yes; I think it might be effected in one day, unless there was any thing materially wrong.

Are not the repairs of those engines necessarily a considerable expense?—Occasionally they are, when any of the principal parts of the machine become broken, or the boilers injured by accident. By having four vessels the machinery might be kept in better order; the state of the boilers better attended to; and, in my opinion, the establishment would be rendered much more certain and effective.

Do you conceive that the injury from neglect to engines is greater than the injury arising from the actual working of them?—Yes, I do.

Has that been a constant defect in the management of steam vessels up to this period?—Yes; I conceive so.

Would you attribute most of the accidents to this neglect?—I should attribute most of the serious accidents to neglect, particularly the accidents to the boilers.

If a vessel goes to sea with its engine in every respect perfectly in order, in your opinion, is it much exposed to injury from the obstructions it may naturally have to contend with?—Not more so than the best constructed steam engines at land.

Then, in your opinion, the engines would, when properly looked after, continue to work without injury or interruption for a long period of time?—For a long time, excepting ordinary wear and tear.

Are you acquainted with any contrivances made use of on board steam vessels for putting out fires in case of accident?—Some of the vessels have had extinguishing engines and hose on board; and I think they should always be provided.

With all the care that can be taken, would it not be better to have every precaution in addition, in the way of sufficient power, to obtain water upon an emergency?—I think it would be highly necessary to have an extinguishing engine.

What do you mean by an extinguishing engine?—An engine for throwing water, either to be worked by the steam engine itself, or by the sailors; it would be very easy to have both; one might be affixed to the engine, and the other might be upon deck. In the instance of the Regent, which caught fire, if they had had an extinguishing engine, or any means provided by which they could have obtained water, they might with the greatest ease have prevented the destruction of the vessel.

Could those extinguishing engines be procured at a small expense?—Yes; I suppose from 30*l*. to 50*l*. according to the size of the engine.

At what expense could an apparatus of this description be affixed to a steam engine?—I suppose 20*l*. or 30*l*. independent of the hose necessary; taking the engine in its most perfect state, it would be a trifling expense.

Could you say what the expense, in your opinion, would be?—I should think there

there would be no necessity to exceed a hundred pounds in its most perfect state, and it would have the effect of giving great confidence to the public.

What quantity of water could be thrown up, do you suppose, by one of those extinguishing engines?—That would depend upon the size of the engine. But an engine of a moderate size would throw much more water than could, in my opinion, ever be required: for in a steam vessel at sea, a fire could rarely or ever happen without its being discovered immediately after its commencement, and in that state a little water well applied would extinguish it.

Do you conceive that the present method of constructing vessels for the purpose of navigation may be much improved?—I believe they may. I have already mentioned Brunton's rotary fire-place, in which the fuel is regularly supplied by the machine itself; and Mr. Brunel's proposed new arrangement of a part of the machinery: both of which, I am of opinion, will be found valuable improvements in steam vessels. I am of opinion also that much may be done towards the improvement of these vessels by attending to past experience. From repeated failures we have seen the necessity of a better adaptation of the power of the steam engine to the size of the vessels; of making the vessels and engines of greater strength; of a more suitable selection of materials; of the inutility of using small vessels and small engines for such a purpose; of the necessity of most carefully guarding against fire by providing a safe receptacle for the coals, and in the construction of the fire-places and boilers; of lessening the quantity of water in the boiler; of preventing the deposition of salt; of increasing the size of the fire-places and flues of the boilers, so as to lessen the labour of the men, and secure an ample supply of steam; for although many vessels have been built possessing some of these requisites, yet very few if any can yet perhaps be said to possess the whole.

Mercurij, 8^a die Maij, 1822.

Mr. Marc J. Brunel, called in; and Examined.

HAVE you paid attention to the subject of steam vessels?—Yes.

Have you been concerned in building any?—In disposing the machinery to a vessel that was built.

Mr. M. J. Brunel.

(3 May.)

What vessel was that?—The Regent.

At what time, in what year?—In the year 1816.

Have you paid particular attention to steam vessels in respect to their qualities for sea navigation?—Those I have seen were not constructed in such forms as to be well calculated for sea, they were as buoyant as possible; they were better calculated to accommodate the machinery than to contend with the element.

Have you seen any of the packets lately built by the Post Office?—No, I have not.

What form of vessel would you recommend as the best for using steam at sea?—I should say that the best water-lines are desirable for navigating, consistently however with the depth of water that may be permitted, according to the navigation.

With respect to the strength of her built, would you recommend that the vessel should be much stronger than usual for sailing vessels?—No; because the strains to which steam vessels are liable, have less of that violence and of those destructive consequences that are incident to sailing vessels. The structure requires therefore less strength upon the whole; but the strength, so far as it is wanted, should be distributed differently, in order to preserve as much buoyancy as possible.

Would you build a vessel stronger than the ordinary strength used for naval service?—Less; on the ground I have stated before.

Do the engines, at present made use of on board steam vessels, appear to you to be imperfect?—The best steam engines I have seen and have heard of, are remarkably well executed. I have, however, considered them as being too complicated for the duties they have to perform against a heavy sea, and deficient too of certain combinations that are indispensable to moderate and restrain their power. Their power should also be employed in a more direct way than it is now; and they should not be cramped by short strokes.

What part of the machinery do you consider, at present, the most defective?—The defects now complained of do not arise so much from the mechanical arrange-

Mr. M. J. Brunei,

(8 May.)

ment of the steam engines, since they are found to perform so well in easy navigation, as from the nature of the service they have to perform, when they are contending against a heavy head sea and a tempestuous wind. It is in these circumstances that the irregularity, sometimes the deficiency, and accidentally the total absence of the resisting medium, that throws the ungoverned and almost irresistible power of the steam engine into those convulsive starts that meet with no other controllable check but the arm of the crank, from which it recoils with increased energy to the opposite side, occasioning thereby those destructive shocks, those alternate strains and wrenchings, which, on frequent recurrence, must prove fatal to the cranks and to the shafts, besides other parts of the machinery. The defective part, therefore, is the want of certain combinations that may enable the engine to adapt and accommodate itself spontaneously to all the exigencies, and to all the perturbations, incident to its peculiar service.

When you say that you would apply the power more directly, to what part of the machinery do you allude to?—I mean the steam engine acting upon the crank.

That is, the interposition of the crank necessarily prevents the power from acting as direct upon the wheels as it ought to do?—Yes; nevertheless, the crank is the most simple, and on that account the most eligible agent we are acquainted with in mechanics, for effecting a rotary movement from an alternate power.

Can you suggest any remedy for that inconvenience?—Viewing the crank as the best medium of connection, I see no inconveniences in its application to wheels; but I propose to remedy the inconvenience now felt by the interposition of certain combinations that will act spontaneously, and that will cause the engine to accommodate itself to all the casualties of the service which it is calculated to perform, so that, in those circumstances, when the resisting medium is partially or totally removed, the power will not be materially increased in its speed, which is the desideratum in relation to sea navigation.

Have you had opportunities of seeing steam vessels at sea?—I have not happened to be in rough weather, but a person who has been nearly five years at sea, as I have been, can judge very well.

Then the great difficulty to contend with in sea navigation is the irregularity with which the engine has to perform its duties?—Yes; certainly.

Must not the difficulty always exist in a great degree as long as it is the practice to have wheels upon the outside of the vessel?—Wheels on the outside have evidently their peculiar disadvantage; nevertheless, as they have been found, by practice, to answer better than any other means, we are equally sure of, I think, that the disadvantages will be very materially lessened if they are kept steady in their action.

Is not the want of space on board the vessel a principal reason for not being able to make the machinery more simple?—No, certainly not; that is, I think I shall take much less room and make it more simple in my plan.

Do you propose to increase the length of the stroke?—Yes; that is a great object.

Is not the present short stroke of engines on board sea vessels occasioned by the want of room?—Yes; but however small the vessel, I can arrange mine so as to answer in all circumstances.

Shall you be able to preserve an equal degree of power in your plan?—More so.

In the present mode of constructing steam engines for sea vessels is there not a very complicated combination of machinery?—It is too great a complication, arising not altogether from a want of room, for many of them are roomy enough, but arising from the manner in which the steam engine is connected with the crank.

Does not that combination occasion a great friction on various parts of the machinery?—It does; and occasions a great absorption of power.

Does not such combination necessarily expose the whole engine to frequent accident from the nature of the element which it has to contend with?—Certainly.

In a vessel of 200 tons burthen, what quantity of power would you apply for sea navigation?—It depends very much upon what speed you want.

Suppose the object be to perform sea voyages through all times of the year and in all weathers?—I think they have in general employed more power than is required, from which it results, that the weight of the boilers, of the fuel, and of a ponderous machinery, are extremely disadvantageous, as it has been found in several instances, when, with a view of making some additions or improvements, they have turned out to be productive of worse effects by lessening the buoyancy.

That

That is, those different circumstances counteract the object of high power?—Yes, it does counteract it very materially.

If those defects which belong to the present system could be removed, should you then say that the power has been generally too great?—Yes; because an excess cramps the machinery still more, and the short strokes are incalculably bad.

For a vessel of 200 tons burthen to be used at sea, which should you prefer, two engines of thirty-horse power, or two of forty-horse power?—I should prefer two of forty-horse power where speed is the only object in view; but for a safe and steady navigation, under all circumstances, I should adopt the smaller power, as being sufficient and consequently preferable.

Would a greater power also contribute to enable the vessel to contend with more advantage against a heavy head sea?—What a greater power might do, would, I have no doubt, be neutralized by those inconveniences to which I have adverted before.

Has it occurred to you to be possible to dispense with the use of wheels upon the outside of steam vessels?—Yes.

Have you made any experiments?—Yes.

As far as those experiments have gone, do they induce you to feel confident that a plan may be discovered by which the use of external wheels may be altogether got rid of?—I believe so, though the vessel might not go so swiftly.

Do you think a vessel so constructed may go with equal certainty and equal power in contending with bad weather and heavy seas?—I think it would.

Have you been concerned in any plan by which some vessel of this sort may be established at Portsmouth for the preservation of lives in case of shipwreck?—I addressed the Navy Board in 1816 upon that subject, in consequence of some successful experiments I had previously made.

Then your plan goes to having a vessel that may contend with the worst description of weather, and for the purpose of affording assistance in case of shipwreck?—My plan was to construct a vessel calculated to do the duty of the buoy-boats, which, when signals of distress or guns are heard, are immediately ordered out to afford assistance; but as the sailing vessel cannot beat against the elements in stormy weather, I proposed to form the body in such manner, and to adapt such machinery, as might contend with advantage against almost any bad weather that may be experienced in these latitudes; allowance made however for those hurricanes when vessels are carried away from their anchors by the mere impetuosity of the wind.

Would it be necessary to sacrifice much of the speed of the vessel?—I dare not say how much or what proportion, because my models were upon too small a scale; they were very satisfactory, but I should not like to decide the proportion.

Have you turned your attention to the manner of applying heat to the boilers of steam engines?—Yes.

What object do you propose to obtain by a change of the present mode?—That the combustion of the coals may be productive of greater heat than it is by the ordinary method.

Has not an invention of Mr. Brunton's contributed very much to improve the method of heating boilers?—Mr. Brunton's invention is very good, but it is expensive, and is not applicable to all circumstances; I am now engaged in carrying on some experiments on a steam engine of my own, upon my plan.

Does your plan promise to be of use to engines on board sea vessels?—Yes; I think it would be very good for them.

Will it prevent the necessity of supplying the fire by hand in the way now done?—The object is not to open the door frequently.

Will it remove the necessity of clearing the fires so frequently as is now required?—That is one of the objects.

Letter to Sir Henry Parnell, Bart.

Sir,

Understanding that the impression left on the minds of the Select Committee of the Holyhead Road, after my examination on the subject of steam vessels, is that my proposed improvements on steam engines are on those denominated the high pressure, I take the liberty of removing that impression by stating, that though my suggestions, in the year 1816, went to recommend, for the peculiar service I had then in view, high pressure steam-engines, as being of lighter tonnage than the condensing ones, I am however well aware that for packets the latter is preferable; and under that impression, those improvements I am now engaged upon, are directed

Mr. M. J. Brunel.
(8 May.)

directed entirely to the qualifying that power for the new service to which it is now applied by the condensing action.

When we contemplate the scale of those steam engines that are introduced in steam navigation, and contrast them with the space within which they are confined, we may easily account for a considerable proportion of their estimated power being absorbed; first, by the want of range of action in the steam cylinder; secondly, by the shortness of the cranks; thirdly, by the complication of the machinery; and fourthly, by the irregularity of the resisting medium upon which their immense power is brought to act. We must further remark, that in this locomotive service any unnecessary power, or any excess of it, is attended with a proportionate appendage which must be carried along and which must operate as an incessant drawback upon the progress of the vessel.

Having had the opportunity, since my examination before the Select Committee, of seeing the largest and best steam vessels that navigate between England, Ireland and Scotland, (some of which with cylinders forty-two inches in diameter, consequently equal occasionally to upwards of one hundred and twenty horse power), and of examining attentively their machinery, I feel the more convinced that there is an excess of power in marine engines, or that with less power an equal effect may be produced.

Now the object of my improvements is, first, to give a longer range of action in the steam cylinder; secondly, to lengthen the stroke of the cranks; thirdly, to simplify the mechanical arrangement; and fourthly, to control and moderate the power, so as to restrain it within a proper and safe rate of action.

In land steam engines we never hear of beams or cranks giving way, of shafts and wheels very seldom; and upon the whole, a steam engine that must work day and night for a twelvemonth meets with hardly any stoppage, and after twenty years of regular service, we find every part, without almost any exception, as sound as when new erected. These advantages are the result of that moderator of action which is peculiar to them, namely, the fly-wheel and the governor. But fly-wheels for moderating a power equal to about one hundred and twenty horses, is obviously impracticable; nevertheless, we may find means that may attain the same end in those confined limits we are restricted to.

I have no doubt but the moderator of power will give to the marine engine a new character. It is now as it were a gigantic untamed animal, which has to go through rocky and uneven ground, dragging by main force its load; or rather, an unwieldy truck with small wheels and large axletrees.

Nothing can be more dangerous than when a land steam engine is accidentally disconnected from its moderator; still the land engines of thirty-horse power are not confined in their mechanical arrangements; all the parts are accessible, and assistance may readily be afforded. But one may conceive what must the convulsive perturbations be, as those occasioned by a power four times as great, exerting its unrestrained energy upon the cranks and the shafts, in a marine steam engine.

Although no material accidents have happened, the mischief resulting from more wear and tear is incalculable, independently of the horror it must add to the situation in which a vessel is during a storm and at night. They have, it is said, exceeded all expectation in contending against the elements; but at what risks, and at what expense? Nevertheless, as they are destined to perform much greater wonders than they have yet done, I flatter myself that the application of the moderator will prove a very material improvement and a very important step in the advancement of that new navigation.

I have the honour to be, Sir,

Your most obedient and humble servant.

Chelsea, 8th June 1822.

Mr. J. Brunel.

Mr. William Evans, called in; and Examined.

Mr. W. Evans.

CAN you suggest any improvements in building steam vessels?—I can make such improvements as will enable us to go a mile and a half, or two miles, an hour faster than at present.

Do you mean by a different method of constructing the vessel, or by a different plan with respect to the engine?—The combined arrangement of the engine and the vessel; neither part will do without the other.

Are you the builder of the Meteor and Severn steam packets on the Holyhead station?—Yes.

Do

Do you conceive that you can now construct a steam packet so that it may have more speed by two or three miles an hour than either of those vessels?—By a mile and a half, or two miles an hour.

Mr. W. Evans.

(8 May.)

Would you make use of engines of greater power?—The same power and the same tonnage, or nearly so, not any material difference.

Would you build a vessel equally strong as those vessels?—Equally strong, on the diagonal principle.

In what way would you render the same quantity of power more available in giving more speed?—I would keep the same nominal tonnage of the boat, but by placing the engines in the centre, with a body of less resistance than in the present steam packets.

Would you make use of the same sized boilers?—The same sized boilers.

Would it be heavier?—Rather lighter.

Would you use one engine or two?—Two engines; one standing before the other, working at right angles; the same in that respect as the present engines.

The whole difference between this plan that you propose, and the plan adopted in the Meteor and Severn steam packets, consists in the arrangement and position of the machinery?—By placing the engines in the centre, we have a sharp body and a smaller resistance, that increases our speed; we cannot have a sharp body by the present method of placing the engines, without keeping them so high as to endanger the stability.

Has any vessel been fitted up with an engine upon this plan?—There have been small vessels upon this construction, merely to try whether they would act with the same power.

Have you put them on board a vessel?—There is one now ready; the steam will be up to-morrow.

What sized vessel is it?—The vessel is fifty-three tons and two eight-horse power engines.

Is the vessel finished, fit to be made use of?—The engines will be at work to-morrow; she will be going down the river on Sunday, I believe.

Who made the engines?—I employed the engineer myself, Mr. Yates. This boat is so small it will not accomplish what I have stated for the packets of eighty-horse, but her speed will be equal to the post office packets of forty-horse power.

Have you built many steam vessels?—Twenty.

Have you been at sea in any of them?—I have been to Margate sometimes, and I have been over in the Holyhead packets.

Are you able to suggest any plan by which steam vessels may use sails with advantage?—A vessel of the description I have mentioned is much better adapted to sailing than the common steam packets.

What sort of sails would you put upon her?—I am not a competent judge of those parts.

What is the name of this vessel you have built?—The Union.

What is the length of her deck?—Seventy-five feet.

What is the breadth of her beam?—Twelve feet.

How many feet of water does she draw?—Five feet.

What sort of lines has she?—The easiest possible lines.

Is she built as a model for a larger vessel, in respect to her lines and shape?—I fitted up the engines with a view of trying what the effect would be.

Is she for the river or for sea navigation?—To run from Dover to Calais and Boulogne.

Luna, 13^e die Maji, 1832.

Sir Isaac Coffin, Bart. a Member of the Committee, Examined.

CAN you give the Committee any information respecting the injury done by salt water to boilers used for steam engines?—I can. In the general average of salt water, there is a gallon of salt to thirty-three and a half of salt water; consequently when the steam, being the aqueous particles of the water, are expelled, the salt is left behind, which adheres to the bottom of the boiler in the shape of a crust, and tends to precipitate the destruction of the bottom of the boilers. At Portsmouth every week or ten days, the men were put into the boilers to remove this adhesion in the shape of salt at the bottom. There are two steam engines at Portsmouth, originally

*Sir Isaac Coffin,
Bart.*

(13 May)

*Sir Isaac Coffin,
R.N.*
(13 May)

put up for the purpose of pumping the water out of the basin that had been before let into it from the docks; the ability of the engines enabled them to throw out 3,000 tons of water in an hour; they also worked the saw mills and the block machinery when not employed in pumping the water out of the basin.

How often was it necessary to clear the bottom of the boilers?—I have said the men were turned in once a week.

Do you know what thickness of crust was formed in that time?—That depends entirely upon the time the engine is employed in those different purposes, or the quantity of steam expended.

Are copper boilers exposed to an equal degree of injury as iron boilers?—Certainly not.

Have you any experience of the superior qualities of them?—Inasmuch as the salt does not act upon the copper in the same proportion as it does upon the iron. The copper boilers have in consequence been substituted at Portsmouth instead of iron; also at New York, the steam boats are all furnished with copper boilers instead of iron; though attended with considerable expense, yet in the end they are found to be cheaper than the iron boilers.

Did they formerly use iron boilers at New York?—They did.

Then they have given them up in consequence of the superiority of the copper?—They have; and in the event of expansion, they are not so subject to accident as iron boilers; for when the boilers split they do not fly off in pieces so dangerously as in iron boilers.

What instance do you know where this has occurred?—In coming from New-haven to New York, passing through Hell-Gate to save her tide and increasing the steam, occasioned the boiler to burst, when no accident happened, the hatchway only over the boiler being lifted a foot or eighteen inches.

Are you acquainted with many of the steam vessels at New York?—I have seen the steam vessels used between Quebec and Baltimore, a distance of seven hundred miles. I have gone in them myself. I have gone from Quebec to Montreal, down Lake Champlain, down the Hudson River, Delaware River, and down the Chesapeake Bay to Baltimore.

Whose engines are made use of in America?—All the steam boats on the river St. Lawrence have Boulton and Watt's engines, and one at New York, the rest are of American fabric.

Do any of the American vessels perform sea voyages?—There is one now that goes between New York and New Orleans, touching at Charleston in the Havannah, having made her voyage constantly without any accident.

For what period has this vessel been on this service?—Between two and three years.

Does she go all the winter?—I cannot answer that question, having been put in motion since I came away.

Mr. Michael Faraday, called in; and Examined.

You belong to the Royal Institution?—Yes.

In what situation are you?—Chemical assistant to that institution, under Mr. Brande.

Have you turned your attention to the action of salt water on boilers used for steam engines?—I have turned my attention to the action of salt water, and the salts it contains, on iron and copper.

Be good enough to state the result of your examination into those effects.—The principal source of injury to iron arising from the salts contained in sea water, when they remain by evaporation, result from the presence of the salt called muriate of magnesia. When in solution, it acts more on iron than its accompanying salts; and when dry, it is decomposed at a heat of 270° of Fahrenheit and upwards, liberating muriatic acid; and this immediately acts upon the metal much more strongly than any other substance which the water contains. Hence, besides the burning of the boiler, which takes place when the metal is coated by the salts, there is this additional strong action from the liberation of the free acid.

In what manner does this muriatic acid act upon the metal?—By causing its oxidation, and forming a soluble salt with it.

Does it act when in solution as well as when gaseous?—In both states.

Would the muriatic acid produce any effect upon the pipes and parts of the engine connected with the boilers through which the steam passes?—If the water were evaporated from the boiler so that the salts should become dry on any part of it, and

Mr. M. Faraday.

and sufficiently hot, then the acid gas would pass into the steam passages and into the cylinder.

Will not this muriatic acid be generated and consequently be passed through the different parts of the engine whenever the degree of heat shall attain 270° Fahrenheit?—That could only happen in the low pressure engines, by the neglect of the engineers in giving a sufficient supply of water.

Is the muriate of magnesia you have described as existing in sea water, constantly acting upon the metal?—Yes; in experiments of four or five hours duration, the solution of the salt was constantly acting upon the iron with which it was in contact.

Is the injury considerable that this salt does to the metal?—Compared with that produced by equal quantities of the other salts in sea water, I should say four or five times greater.

What other salts are deposited in the evaporation of salt water?—Muriate of soda, muriate of lime, sulphate of lime, and some other salts in very minute quantities.

Do each of these salts injure the metal?—They each, when in solution, as in sea water, injure the metal more than pure water would do; but none of them so much as the muriate of magnesia, and none of them liberate muriatic acid by heat alone.

Do your answers apply to the action of the salts upon iron or copper?—To the action on wrought iron.

Do those salts produce as much injury on copper as you have stated they produce upon iron?—By no means.

Can you say in what degree the difference of injury is?—I have not had time to extend my experiments to precise results on copper.

Can you say that the difference of action is very considerable?—Very considerable.

Is it so great as to induce you to give a decided preference to the use of copper over iron in cases where salt water was necessary to be used for evaporation?—

Does not the formation of the salt in crusts upon the bottom of the boiler very much diminish the action of the fire upon the water in producing steam?—Certainly. Yes.

If the force of the fire is not expended in producing steam in the degree it ought to do, supposing no such crust to exist, will not the degree of heat which ought to pass through the bottom of the boiler to the water, go along the flues, and thereby contribute to burn and destroy them?—Yes; supposing the flues are of materials to be injured by heat.

Have you tried any experiments to ascertain the manner in which the different salts contained in salt water are deposited by heat?—I have. Taking 1,000 parts of sea water by weight, and evaporating, I found that 825 parts nearly of steam could be driven off before any deposition commenced, but then sulphate of lime was deposited; on proceeding with the evaporation till about 110 parts remained, the common salt began to crystallize and deposit; on continuing the evaporation till only 35 $\frac{1}{2}$ parts remained, the muriatic acid from the decomposition of the muriate of magnesia began to separate.

In boilers containing large quantities of salt water and giving steam for working engines, are those depositions of salt continually going on?—That will depend upon the water supplied to the boiler; if the whole of the steam were condensed and returned into the boiler, there would be no concentration of the water contained in it; but if there is a loss of steam and sea water be supplied to the boiler in its place, a deposition of salt will take place, more or less rapidly, according to the loss of steam.

It is in this way the concentration takes place of the body of water which produces in the result these crusts upon the bottom of the boiler which occasions so much injury?—Just so.

Is it easy to ascertain the degree of concentration which takes place?—Very easy.

What is the process?—I would recommend an hydrometer, an instrument the workmen could easily apply without any trouble.

The person in the care of the engine could at all times ascertain the state of the water in the boiler?—Yes; he would have to draw a small portion out, which he could easily do I suppose, and then apply the hydrometer to it.

Have you turned your attention to any remedy for the inconvenience arising from the use of salt water in steam boilers?—If possible, the use of fresh water would remedy it; and if that is not possible, I would suggest the removal of the sea water

Mr. M. Faraday.

(13 Mar.)

in the boiler before it be too much concentrated, and the supply of fresh portions of sea water; precautions being taken to supply them in such a state that they would do no injury, or cause any intermission to the working of the engine.

Where it is possible to obtain fresh water for boilers, should not care be taken in selecting the kind that is made use of?—Certainly.

Are you acquainted with any instances of injury to the metal parts of the engines arising from the use of foul fresh water, or water impregnated with earthy salts?—Every furrowed tea-kettle offers an instance of this kind of injury. In them the same process goes on as in many boilers in Cornwall. There are instances where considerable depositions of carbonate of lime have taken place in boilers from the use of water containing calcareous matter. There are two specimens at the Royal Institution of considerable depositions in pipes from the passage of calcareous water through them; one of them being, I believe, the feeding pipe to a boiler, and being nearly two-thirds choked with earthy matter (carbonate of lime).

Has the cold salt water much influence upon iron?—Yes, it acts much more strongly than cold fresh water upon it.

Does it act upon copper and brass with equal force as it does upon iron?—No.

Could any chemical means be made use of to counteract the injury occasioned by the several salts contained in the boilers of steam engines using sea water?—I know of none to counteract the injury arising from the muriate of soda and muriate of lime; but I should think it probable that, arising from the presence of muriate of magnesia, might sometimes be advantageously corrected by the addition of either lime or the alkalis to the water before it be introduced into the boiler; I suggest this merely from theoretical views; but such additions would produce the salts found by experiment not to be so injurious to the iron as the muriate of magnesia.

What portion of the water contained in the boiler may be raised into steam before the salt is deposited?—About eight-ninths, not quite nine-tenths, before the salts are deposited.

Does it occur to you, that, with common care and attention on the part of the persons entrusted with the supply of water to boilers, that this deposition might be prevented?—I conceive there would be no difficulty in supplying hot sea water, and in withdrawing portions of the concentrated water in the boilers in such a manner as to preserve the whole mass below the point of deposition.

Would you say this could be done for many hours successively?—I should think for days, weeks, or months successively. It is the only mode that occurs to me of preventing the salts from being deposited in the boilers, and I think it easy to put in practice.

After the voyage is completed, the whole engine necessarily becomes cool, will not, in that state, the salt deposit very rapidly?—If this operation were resorted to, the water in the boiler should never be in a state to deposit crystals; it never would be in that state.

Then, by using the precautions you suggest in preventing the concentration of salt water, the business of emptying the boilers after the voyage might be performed without any considerable deposition of salt?—If the means of prevention suggested are applicable, they should entirely prevent the tendency of the water to deposit salt in any state or at any time, and then it may be drawn off without leaving any crust at the bottom. I should mention, that there is a salt deposited from sea water, the sulphate of lime, which would form a crust at the bottom, but in small quantity, compared to that produced by the muriate of soda; it would require cleaning out sometimes. However, four-fifths of the sea water might be evaporated before even this deposition would take place.

Do those salts when decomposed fasten strongly on the metal or become incorporated with it?—I should think that would depend much upon the state of the boiler; they would probably in most cases form hard crusts adhering to the bottom.

Can those crusts be easily removed after the water is drawn off?—It is a hard crust, and would probably require considerable labour to pick it up.

Do those crusts contribute considerably to prevent the proper application of the force of furnaces upon the water in the boiler?—They prevent, to a very considerable extent, the transmission of heat through the bottom of the boiler to the water, in consequence of their bad conducting powers as regards heat.

Are they worse conductors than the metal itself?—Very much so.

Can you state to the Committee what effect these crusts have in the diminishing the making of steam according to the quantity of fuel consumed?—It would require considerably

considerably more fuel to raise the same quantity of steam, but I am not able to give a proportion.

Do these crusts contribute to hasten the burning of the bottom of the boiler?—Yes, by preventing the transmission of the heat through the bottom of the boiler, the metal itself becomes much hotter than it ought to be, and consequently burns away much sooner than it should do.

If so much heat not being transmitted through the bottom of the boiler, it follows that the flues must become hotter than they ought to be, and thereby be considerably injured?—Yes.

Have you tried any experiment to show what salts a cubic foot of sea water contains?—I have only estimated it as regards the muriate of magnesia, that being the most injurious salt. The cubic foot of sea water weighs about 1,026 4 ounces, avoirdupoise; it contains 3.28 ounces of muriate of magnesia, which, if completely decomposed by heat, would give rise to 2.13 ounces of muriatic acid; this is able to dissolve or corrode 1.6 ounces of iron; and if it were found useful to decompose this muriate of magnesia, it would require 1.64 ounces of quick lime, or 2.78 ounces of dry potash, or 4.1 ounces nearly of common pearl ash.

What quantity of copper would the muriatic acid, capable of being separated from the cubic foot of water by heat, dissolve?—The utmost quantity would be 3.7 ounces, but the probable quantity from the nature of the salt found, would be one half or 1.85 ounces. Copper is much less liable to the action of muriatic acid than iron is.

Charles Williams, Esq. called in; and Examined.

HAVE you turned your attention much to steam vessels?—A good deal.

Have you had an opportunity of seeing and sailing in many of them?—I have seen and sailed in almost all the steam vessels on our coasts.

What occurs to you to be the principal defect in the machinery now generally in use?—I conceive the engines nearly as perfect as ever they will be, that is to say, all inside the vessel. The external wheels appear to me to be almost the sole ground of inconvenience and mischief.

In what manner do the wheels operate to produce obstructions in the way of the proper speed and the power of the vessels?—The violent action of the paddles in a heavy sea striking the water, shakes and strains both the vessel and machinery, and produces what Captain Percy of the *Hero* has very well described, as having a tendency to drive the top and bottom asunder; the result of this severe action is, that the engine loses its speed, and scarcely performs one-half or one-fourth of what it should do.

Has any plan come under your observation, by which these inconveniences can be removed?—Yes; there is now a plan adopted in the *Waterloo* plying between Dublin and Liverpool, and in the *Havre-de-Grace* iron steam vessel now on the Thames.

Be so good as to describe it to the Committee.—The paddles, instead of being fixed as in the common wheel, revolve with a continuous motion on their own centres; the result is that they always enter and rise out of the water with a soft and easy motion, no matter what their immersion may be.

By whom was this plan invented?—Mr. Oldham of the Bank of Ireland.

Have you made a voyage in the *Waterloo*?—I have.

In what sort of weather?—Extremely severe weather.

Was the sea very rough?—As heavy a sea as I ever saw in the Channel.

Did the paddles answer their purpose?—Remarkably well.

Was the voyage in your opinion a fair and complete trial of the efficacy of that plan?—Decidedly so; the *Waterloo* made her passage several hours sooner than she could before under the same circumstances.

Was the wind adverse?—The wind was not adverse; part of the way the wind was on the beam. The vessel then lay on her side; the wheel was occasionally so deeply immersed as to be nearly axle deep, notwithstanding which the paddles worked as smoothly and as efficiently as if the vessel had been upright.

Did the wheels perform their evolutions in the regular and proper time?—They did. On leaving Liverpool the first day the new paddles were tried, the *Waterloo*, which was always a very heavy sailer, made her passage nearly as quick as the *Belfast*, which is a very quick one. The *Belfast* sailed an hour and a half after the *Waterloo*; the *Waterloo* was in considerably before her.

Is the *Belfast* reckoned a good steam vessel, and does she make quick voyages?—One of the best and quickest on the station now in use.

Mr. M. Parvosty

(13 May)

C. Williams, Esq.

C. Williams, Esq.
(23 May.)

What will be the great advantage which may be derived from this new plan of paddles?—All the straining of the vessel which is occasioned by the old paddle wheels would be removed; the engines also would work as smoothly and without jerking in rough as in smooth weather. In coming to anchor in a tide way, as at Liverpool, the paddles are no drag on the vessel's way, and prevent her dragging her anchor. Again, in case of accident at sea, the paddles being placed edgewise, enable the vessel to use her sails to advantage; the vessel's head also may be brought about instantaneously, and without stopping the engine, by placing the paddles on one side edgewise; those circumstances have all occurred within my knowledge.

Is not the present limit of the use of power of steam on board vessels occasioned by the necessity of increasing the size of the wheel in proportion to the power?—Decidedly so. I know no way of applying the power of large engines without a dangerous increase of the size of the wheels.

Will not it therefore be practicable to make use of a much greater degree of power than has hitherto been used if this plan of paddles shall prove to be as efficacious as you have described?—Certainly so; any extent of power may be used without straining the vessel or causing any injury, consistently with the size of the vessel.

Will those paddles work when more immersed in the water than the paddles now in use commonly are?—It is indifferent to the action of these revolving paddles how deeply they may be immersed. Were the revolving paddles at present on board the *Sovereign*, one of the Holyhead packets, the projection might be diminished two feet on each side.

Is it difficult to substitute those paddles for the paddles now in use?—They may be substituted without any alteration of the vessel, merely taking out the old wheel and putting the new one in its place.

In the voyage you made in the *Waterloo* did any of the paddles give way?—Nothing gave way.

What is the power of the engine?—The maker estimates them at two thirties; but according to Mr. Watt's calculation they are but little more than two twenty-fives.

What is the tonnage of the vessel?—Two hundred and ten tons; she is very clumsily built, and originally intended for a trader; bluff in the bows and very heavy behind, and twenty-two feet beam. The captain of her writes to the following effect, after having had repeated opportunities of proving the efficacy of the paddles; he says, "The easiness of the motion through the water is wonderful; instead of the violent shaking which was formerly the case, it is now scarcely perceptible that the engine is going. They are beyond a doubt a great acquisition to the *Waterloo*." I have in my hand a description of these paddles, which I beg to deliver in.

[The Witness delivered in the following Paper.]

THIS invention has been found to remedy the many defects to which the common wheel with fixed paddles must ever remain liable. It has already been successfully adopted on the *Havre-de-Grace* iron steam vessel, and on the *Waterloo* now plying between Dublin and Liverpool.

In order to remove any apprehension as to the liability of the revolving paddles getting out of order, the patentee will warrant them for twelve months, if made under his own directions, or by manufacturers approved of by him; injuries arising from neglect, being run foul of, or other violence, excepted.

Advantages resulting from the use of the Revolving Paddles.

First.—The violent action of the paddles of common wheels in striking the water in a rough sea, which shakes and strains both the vessel and the machinery, is entirely removed by the use of the revolving paddles, as they enter and rise out of the water with a peculiarly soft and easy motion.

Secondly.—The revolving paddles cause the engines to work as smoothly and as efficiently in rough weather as in a calm. When a vessel with fixed paddle-wheels rolls, and the paddles become deeply and suddenly immersed in the water, the engines do not make one-half or one-fourth their required number of strokes per minute; not unfrequently they are then so overloaded as to stop altogether, the paddles thus become a source of great danger, and check the vessel's way at the moment when their propelling power is most required.

Thirdly.

Thirdly.—When a vessel is carrying sail with a side wind, it often becomes necessary to take in the sails, and sacrifice all the advantages and speed derivable from the wind, otherwise the leeward wheel (in consequence of the vessel laying over,) would be so deeply immersed as to work to great disadvantage, and even to impede her way. This very serious inconvenience is entirely obviated by the revolving paddles, which work equally well when axle deep in the water, as when the vessel is upright.

Fourthly.—In bringing the head of the vessel about in a narrow tide way, or when the sails are taken aback by a sudden shift of the wind, the revolving paddles afford the greatest assistance. In such cases, the paddles on one side of the vessel may instantaneously, by any ordinary seaman, and without stopping the engines, be placed edgeways to the action of the water; the entire power of the engines then acting on the other side, causes the head of the vessel then instantly to come about. This is effected without the smallest violence to either the vessel or the engines.

Fifthly.—As it is indifferent to the action of the revolving paddles how deeply they may be immersed in the water; vessels furnished with them are enabled to carry a heavier freight than if appointed with common wheels, as the latter cannot work to advantage if immersed more than twenty inches, or two feet.

Sixthly.—In case of accident to any part of the engines or boilers, when at sea, the revolving paddles may be placed edgeways, and by thus presenting no impediment to the vessel's way, she is enabled to use her sails to the greatest advantage. Should the wind be then on the beam, the paddles have the additional advantage of acting as lee-boards.

Seventhly.—As the revolving paddles cause no loss of power in striking the water, as they enter or rise out of it, vessels appointed with them go much faster than if furnished with common wheels.

Eighthly.—The revolving paddles do not require so large an external projection as common wheels do. Where the engines are above thirty-horse power, the projection for common wheels is so great as materially to affect the ease and safety of the vessel in a rough sea. (See Captain Percy's evidence.)

Ninthly.—Vessels with revolving paddles are enabled to employ to advantage engines of much greater power and with commensurate speed, than if fitted with common wheels. Vessels with common fixed paddle-wheels, like the Post Office packets at Holyhead, when running before the wind in a gale and a heavy sea, cannot employ the full power of their engines with safety, the wheels then running two or three times round without touching the water between the trough of the sea, and then being brought up all at once, are in great danger of causing some part to give way. (See Captain Rogers's evidence.)

Has the *Waterloo* performed many voyages with those paddles?—Several.

Is she regularly plying between Dublin and Liverpool?—She is; she crossed once in fifteen hours, and once in fourteen hours; and formerly with her old paddles, under no circumstances of wind or tide, could she have done it within four or five more.

What is the distance from Dublin to Liverpool?—130 miles.

Is there on board the *Waterloo* that vibration so sensibly felt in all other steam vessels?—At present there is not; formerly that was peculiarly unpleasant; and the *Waterloo's* engine, not unfrequently in rough weather, stopped entirely, and remained so for many minutes before the engineer could get her on again.

Is the engine now in her, exactly the same as formerly?—Precisely.

Were the paddles formerly in use of common construction?—Yes.

Who was the maker of the engine?—Scott, of Glasgow.

Are those new paddles strong in their mode of construction?—They may be made as strong as an anchor. Another advantage attending the use of Mr. Oldham's paddles is, that the projection outside the vessel is considerably diminished.

Do you know the breadth of the projection on the *Waterloo*?—The paddles are five feet wide, they were six and a half.

What is the effect of those paddles on a vessel going before a gale of wind in a heavy sea?—That is the time she ought to go the quickest.

Can you use the whole steaming power?—Entirely.

Have you been on board other vessels under such circumstances?—I have; but they were obliged to shut off a great portion of steam, as Captain Rogers has observed, to diminish the action of the wheels on the water, and which strained the vessel considerably.

Mercurii, 22^a die Maij, 1822.

Mr. Joshua Field, again called in; and Examined.

Mr. J. Field.

(21 May.)

IN your experience have many of the accidents that have happened to steam vessels when used at sea been owing to the negligence of the engineers attending them?—Sometimes from that cause, and sometimes from other causes; for instance, the vessel straining at sea.

Does not it require a very diligent attention on the part of the engineer to keep the engine constantly in good order?—Yes.

What are the principal injuries that may arise from neglect on their part?—I think the greatest evil to be apprehended is to the boiler, their neglecting to feed it properly with water, and change it frequently.

What is the consequence of that omission?—Burning the fire place, and destroying the flues.

And also burning the boiler?—Yes.

What other injury follows from the neglect of the engineer?—From inattention the engine may get loose in all its parts, which occasions a violent blow on each returning stroke, and is liable to break itself from that cause.

May it not be injured from some parts of it, for instance, the bearings being allowed to get too hot?—Yes, from the other extreme, the joints or bearings being too tight.

Any others?—It is exactly the same as other machinery in that respect.

It has been stated to the Committee that the condensed steam resting at the top of the piston is productive of danger?—That objection I consider is completely obviated.

That is in your plan, but where your plan is not adopted, how is it?—Then it is liable to that injury.

Suppose an establishment of four steam vessels, for the purpose of crossing the Irish Channel backwards and forwards every day, at all times of the year, and in every sort of weather, short of downright hurricanes, in your opinion would it be expedient to appoint a professional man to superintend the engines of those vessels, and the conduct of the working engineers?—I think it would; in every large establishment, both public and private, where much machinery is used, it has been found necessary to have such a person; as at the Royal Mint, and the Dock Yards, Portsmouth, particularly.

That is, a person to be over the operative engineer?—Yes, as well as having the means of making repairs. I allude to some sort of establishment, such as a smith's work-shop, lathe and other tools.

What description of inspection would you propose; that of occasional visits, or that to be performed by a constant resident inspection?—A very frequent examination would be most likely to keep the engines in good order.

Would it not be advisable that every vessel after every voyage should be examined by an inspecting engineer?—It would render it more certain.

As the preservation of the engine and the safety of the passengers altogether depends upon all parts of the engine being kept constantly in order, could this business of inspection be executed in a certain and effectual manner in any other way than by a resident engineer?—I think not.

What is your opinion with respect to the use of copper in making boilers for engines?—I think for sea vessels it is the only material that ought to be used.

Is there any other part of the engine that ought to be made of copper?—The bolts through the bottom for fixing it should be of copper.

Should the steam pipes be of copper?—Copper is a good material for the steam pipes, from its being less brittle as well as more lasting.

Is there any part of the machinery that ought to be made of brass instead of iron?—The air pumps, the hot water pumps, and those parts most exposed to the hot salt water, should be of brass for sea vessels.

Are you of opinion that the present mode of forming furnaces on board steam vessels might be improved?—I am not aware of any, except the introduction of the revolving fire-place.

Do you think that plan of a revolving furnace might be applied to engines on board vessels?—I have no doubt of it; I think it would be very advantageous.

Has it yet been attempted?—I believe not.

Do you know what objections have been made to trying the experiment, or whether any attempt has been made so as to show whether there exist any objections or difficulties?—I am not aware of any; I never heard of any difficulty.

Would that plan require more room than the present plan of furnace?—I do not think it would; the surface of the fire-grate might be a less area than it is at present, in consequence of the advantages resulting from the principle.

Mr. J. Field.

(21 May.)

Mr. Alexander Gallowsy, called in; and Examined.

ARE you well acquainted with steam vessels?—Yes; tolerably well.

Have you made engines for any?—I have not made any large engines for this purpose, although I have been concerned in the engineer's company for the last four or five years; I have built them for small vessels.

*Mr.
Alex. Gallowsy.*

Have you given the subject a good deal of consideration?—Yes, I have; both scientifically and practically.

Is it your opinion that steam vessels for sea navigation may be considerably improved?—Certainly; I consider the thing quite in a state of infancy.

Suppose a vessel of two hundred tons burthen, if such a vessel would admit of two fifty horse engines being put into her, would you prefer two such engines to two forty horse engines?—If her sectional area required the greater power, I should do so.

What do you mean by her sectional area?—I mean the area of the transverse section of the vessel, that is her breadth or beam multiplied into her depth of the draught of water. The quantity of power must always depend on the form and construction of the vessel.

If a vessel was constructed of a proper form as to the line of flotation, would you use as much power as you could put into her?—Up to a certain velocity only; because I never think of attempting to get a vessel to go more than ten miles an hour, as any greater speed would be an unprofitable application of power.

Does your answer relate to vessels going through still water?—Yes.

What would be the rate of speed which you would endeavour to obtain, supposing you were to contend against a heavy head sea, and a gale of wind directly contrary to your course?—Certainly with an opposing current or wind equal to a resistance of five miles an hour, she would only make progress at the rate of five miles an hour; if she was calculated to go through still water at the rate of ten; then under such circumstances it would be desirable to have an augmentation of power such as would enable her to go twelve in still water, but in fact with an opposing wind, as before stated, she would only go seven miles on her course.

What is your opinion with respect to the degree of strength that should be given to every part of an engine to be used at sea?—I think they cannot well be made too strong in the *actional parts*, with due regard to the measure of power.

By what means, in your opinion, may we look forward to any considerable improvement in the present plan of constructing steam vessels for sea navigation?—I should think the most certain and economical mode of effecting it would be to offer a parliamentary reward sufficient to stimulate the most experienced talent in the country; and, to render that reward more efficient, government should give all the facilities with respect to fixing and furnishing the vessels, because the want of vessels to put machinery on board for trial has been a great retarding cause to the improvement in this branch of navigation.

Are the experiments necessary for trying the merits of this sort of improvement very expensive?—Unavoidably so.

In what way would you propose that such parliamentary reward should be controlled, so that the money may be made available for its object?—The details of such a plan would, perhaps, require more consideration than I shall now be able to give it; but, I think I can, perhaps, give sufficient information upon the subject to justify a further consideration of it. I think, that if pecuniary rewards were offered for sea-going vessels, and for river navigation, fixing certain proportions of reward to the one and the other, stating the capacity of the vessel, the rate of going, and the various states of weather, which of course must be stipulated, because her progress through the water would be in different weather variable, and therefore there must be some circumstances laid down that the vessel should be capable of being tried by: now, I think, if a Board were appointed, consisting of some clever-men and experienced navigators and a few experienced engineers, to whom plans might be submitted, who might say, this is what we want in point of velocity, this is what we want in point of power and capacity; and that class of machinery that will attain these objects most effectually, both in reference to

Mr.
Alce. Galloway.
 (22 May.)

economy and safety, will be that entitled to the reward. Then I should say at once you might have a great many plans submitted to you, many of which, would, perhaps, upon the very face of them, be so obviously inconsistent and inefficient, that there would be no difficulty in saying at once this cannot be tried; but those which were thought favourably of should be tried at the expense of the engineer; and a man would pause a little before he would go and spend so much money, and he would not be satisfied to trust his own opinion; at least I, for myself, should not be satisfied with my own knowledge, but should submit it to some persons who might be able to give me advice, and when it was submitted to such a Board, if they should think favourably of it, they would say, we will fix it for you, under your direction, and if it should be, after fair and sufficient trial, adopted, the reward would be given.

Would you propose that the person suggesting such improvements should be made to bear a part of the expense?—The whole, as far as regards the machinery; that would, in my opinion, keep down idle and visionary projects.

Are there not many improvements now in contemplation which promise to be successful, that cannot well be subjected to a proper experiment without incurring a very considerable expense?—So great an expense that few individuals would have courage enough to embark in them.

What are the chief objects to which the engineers should apply their attention for the purpose of improving engines now in use for sea-going vessels?—I should think compactness in the first place; simplicity, power, and peculiar strength of construction, with a due regard to as great a reduction of the weight as possible.

With respect to wheels and paddles, is there not room for considerable improvement?—I think there is; I will instance a case I tried, as I mentioned in the early part of my observations, with internal paddles upon a vessel of 500 tons, which the engines with the ordinary paddles never did propel in still water at a greater rate than two miles per hour, which the same engines with a vertical paddle, and in the same state, and under the same circumstances, were made to propel the vessel at the rate of five miles and a half an hour; the vessel drawing ten feet of water and being twenty-eight feet beam.

What is a vertical paddle?—A vertical paddle is one that always retains its vertical position as it enters and quits the water upon its edge.

Are the present engines in your opinion very defective in consequence of their great weight?—I think they are so far defective as weight is an injury to a vessel; but they are also defective inasmuch as they take up that room which can be ill spared. On land situations it was never a very important object with an engineer to consider the least possible space that he could put an engine into; but on board a vessel it is a great object to gain compactness.

Then it becomes necessary so to contrive and form the vessel as to get rid of that great weight which has hitherto been found injurious?—I think so; the class of engine, in my estimation, that will ultimately be found the best calculated for steam vessels will be rotary engines.

Will you state the reason?—The reason why I think that rotary engines will be best calculated for steam vessels is, that you would obtain circular motion for the paddles directly from the steam cylinder, without the intervention of any machinery whatever.

Is much of the power of the steam lost, at present, by the various combinations of the machinery?—Certainly.

Are many of the accidents that occur to be accounted for in the same way?—In proportion to the multiplication of the parts of steam engines, they are liable to breakage and accidents in this way.

You were examined some years ago on the subject of high pressure engines?—I was.

Your opinion at that time was against the use of them on board steam vessels, do you entertain at present the same opinion?—Certainly not, as to the inexpediency of using high pressure engines.

What circumstances have induced you to change your opinion?—The circumstances that have induced me to change my opinion are, that the public are now much more familiar with steam engines than they were at that period, there are no false notions on the subject now, and the advantages that have resulted from their use have become so many and so conspicuous, that a man would now no longer consent to give up the use of a steam engine in a vessel, because an accident might happen on board, than he would give up a carriage because the axle-tree broke; for ships of war I should have no hesitation at all in saying, that a high pressure engine would be

be the best, because there would be good discipline and regulation, which would ensure their safety.

Are the high pressure engines much in use?—In America they are, but not at all in England in steam vessels, to my knowledge.

Are they able to construct them in such a way as to prevent accidents?—I think they may be rendered considerably safer than we have any example of at present.

What are the general advantages of high pressure engines?—The great advantage is, that they produce compactness, an immense power in a small compass, and comparatively little weight.

Are you of opinion that a high pressure engine may be so constructed as to be made safe?—I think so.

Supposing an establishment of four steam vessels to perform the public service of carrying the mails between Holyhead and Howth, which requires one to sail from each port every morning in all sorts of weather, and throughout the year, are you of opinion that such vessel ought to be left entirely to the charge of the working engineers that are on board them?—Certainly not; they would indispenably require on each side a superintendent engineer.

Do you mean a professional engineer?—I mean a man who would be acquainted with the general theory of the subject, and intimate with the practical operation of that theory, so as to be able to perceive casualties, and to see the probability of breakage and injury, when perhaps it would altogether escape the observation of a mere working man.

You mean then a person who has been in the habit of superintending the practical operations of engineering, and not a mere working engineer?—Certainly.

Might not one inspector be sufficient, supposing the arrangements to be that the packet sailing from Holyhead should return the next day, so as to confine all the packets as much as possible on the Holyhead side?—I should consider that one on either side would be of great service, yet I think one on both sides would be of much greater; but I consider it would, perhaps, for a first attempt, be quite sufficient that one of such individuals should be placed on either side.

In other great establishments, where much machinery is in use, is it not the practice to have inspecting engineers of the description you have mentioned?—Invariably so, and also the means of correcting any part of the machinery that may suddenly require repair.

You allude to forges and other means of repair?—A turning lathe and all sorts of means which an engineer requires in his manufactory to perform work of that sort.

Is not the time and attention of the operative engineer sufficiently taken up by the business belonging to the voyage?—Sufficiently so; it would be most unwise to engage his attention in any thing else.

Would not such an arrangement of constant inspection, contribute essentially to the preservation of the machinery, and thereby to a saving of expense?—I should do it as much for the sake of economy as any thing else.

Would it not also contribute to the safety and convenience of the passengers?—Certainly, to their convenience; I should think to their safety, as far as securing the use of the engines in the vessel under all circumstances.

Sabbati, 1^o die Junij, 1822.

Mr. Michael Faraday, again called in; and Examined.

WHAT is the temperature most favourable to crystallization of a water concentrated by evaporation?—The lower the temperature the more favourable for the deposition of the salt.

At what degree of temperature and saturation do the different salts contained in sea water first begin to be deposited?—If a certain quantity of sea water be taken, 1,000 parts for instance, the following are the points of deposition. The boiling point of the water at first is nearly 214° Fahrenheit; when 701 parts of steam have been driven off, the remaining 299 parts begin to deposit sulphate of lime, the boiling temperature then being 217°F; when 898 parts have been evaporated, the remaining 102 parts begin to deposit common salt, and boil at 228°F; if all the water be evaporated, about 30 parts of salt remain. These are the points which occur in a close vessel at the pressure of the atmosphere. That which relates to the sulphate of lime differs from the estimation I before gave, but I have made the last experiment very carefully, and am willing to trust to it.

Mr. M. Faraday.

(1 June.)

Mr. M. Faraday.

(1 Jan.)

What is the temperature at which sulphate of lime begins to be deposited?—
217° of Fahrenheit, very nearly.

Would a dry holly or thorn bush introduced, if practicable, into the boiler, take off a part of the crystallization which would otherwise adhere to the bottom of the boiler?—I should be afraid only a small part, too small to be of any importance; the agitation of the water in the boiler from ebullition, would prevent the crystallization taking place on the holly bush as a nucleus, but the crystals would be formed throughout the whole mass, and would fall, by their gravity, to the bottom of the boiler.

Would any known extraneous matter put into the boiler have the effect of attracting the sulphate of lime, in lieu of its attaching itself to the sides or bottom of the boiler?—I am not aware of any such substance in the circumstances of a steam engine boiler.

Would the filling a boiler with river water in the first instance, on the departure of a vessel for a voyage of seven or eight hours, be of any importance in obviating the difficulties alluded to?—That would depend upon the whole quantity of water used for the voyage. If the quantity taken out in the boiler were small, compared with the quantity to be added from the sea, the good effect would of course be small also.

Supposing the consumption of water to be at the rate of forty-five hundred weight per hour, and the voyage to last seven or eight hours, how much concentration would take place?—I cannot answer the question without knowing the quantity of water left in the boiler; but such a consumption for eight hours would reduce 513½ cwt. or nearly 26 tons of sea water, to the state in which it would begin to deposit sulphate of lime, or 400½ cwt. (about 20 tons) to the state in which it would begin to deposit common salt. The remaining concentrated portion would weigh, in the first instance, 153½ cwt. nearly, and in the second 40½ cwt. nearly.

In what manner is the muriatic acid produced in boilers of steam vessels?—In the evidence I have read, mention is made of crusts of salt having formed on the bottoms of boilers; the interposition of these crusts, which are very bad conductors of heat between the boiler and the water, prevents the free transmission of heat that ought to take place; and the bottom of the boiler, with the under side of the crust, is in consequence heated to a higher temperature than the water itself; this undue accession of heat increasing with the thickness of the crust; when the elevation of temperature reaches 270° or 280° and upwards, all that portion of muriate of magnesia included in the crust so heated will be decomposed, and its muriatic acid evolved in a free state; also, if by carelessness the sea water in a boiler, having the flue passing through it, should be suffered to sink by evaporation below that flue, any salt deposited on the upper surface of it would then be liable to an elevation of temperature much above 270° or 300°, and would in consequence have the muriate of magnesia contained in it decomposed, and the muriatic acid evolved.

Have you turned your attention to the different qualities of coal, in respect to their tendency to fire spontaneously, when put together in large heaps?—I have not had an opportunity of witnessing the effect, but the general chemical principles I am acquainted with.

Have the goodness to state them?—The inflammation of the coal in such circumstances, almost always, if not quite always, depends on the action of moisture and air on the pyrites they contain; when the pyrites in the coal are moistened and exposed to air, they are decomposed with the production of heat, and portions of the sulphur contained in them, with gaseous combustible bodies, being liberated, they inflame and produce the ignition of the coal; the commencement of the combustion I believe always takes place in this way.

That is without coming into contact with any ignited body?—Yes.

Does this tendency to firing spontaneously depend upon the quantity of pyrites in the coal?—It depends partly upon the quantity, and partly upon their state; some kinds of pyrites are more liable to decomposition than others.

Do the different kinds of coal differ very much, in respect to the quantity of pyrites they contain, and to the different kind of pyrites?—I believe very much, but I have not an accurate knowledge of the varieties of coal raised in this country.

Is the spontaneous firing of coal a circumstance likely to happen frequently?—That depends entirely upon the circumstances of the quantity and the quality of the coal, the degree of dampness, and the degree of heat.

Then in selecting coals for the use of steam vessels at sea, great care should be taken first of all in selecting the coals, then in putting them together in a dry state, and then that they are not unnecessarily exposed to a high degree of temperature?—

Yes;

Yes; but I am not sufficiently aware of the quantity, and other circumstances of coals generally stowed in vessels for long voyages, to say whether the precautions which would be necessary at the pit mouths are requisite on board the vessels; if the quantities stowed at once are but small, and the coals are continually, day by day, changed, and the temperature moderate, I should think there was very little probability of injury.

Mr. M. Faraday.
(1 June)

Have you ever known any instance of a spontaneous ignition of coals in a steam vessel?—No, I have not; I may remark, that coals, which in common circumstances would have no tendency to heat and inflame spontaneously, would have a tendency at a higher temperature; but it would be very easy in the coal boxes on board of vessels to ascertain the general temperature of the mass of coals, by having an iron tube across the coal box, into which a thermometer could be introduced, when if any increase was observed, it would be evident that there was a tendency to heat and inflame.

Royal Institution, May 7th 1822.

THE following Remarks are intended to accompany the evidence I have been called upon to give before the Committee on Holyhead Roads. The nature of an examination will not always admit of the information required being put into the best form; and as some rather refined sources of probable injury have been stated, and other sources insisted on, which have not been generally noticed, it will be of advantage to have the whole placed in one connected view.

With regard to the composition of sea water, the following numbers are very nearly correct, and accord with the best analysis. Its specific gravity varies a little in different parts of the ocean, from the vicinity of mouths of rivers, ice, evaporation, and other causes, but may be estimated as a mean at 1027, pure water being 1000. When of a specific gravity of 1027.2, being such as I used in my experiments, one cubic foot of it weighs 1026.265 ounces avoirdupois; and contains,

	Ounces.
Common salt - - - - -	25.762
Muriate of magnesia - - - - -	3.282
Sulphate of magnesia - - - - -	2.212
Sulphate of lime - - - - -	1.013

32.27

Besides small quantities of some other salts, which however are in proportions too minute to be of any consequence.

When any of these salts in their pure and separate state are dissolved in water, and left in contact with iron, or are boiled with wrought iron in a close vessel analogous to a steam-engine boiler, corrosion of the iron takes place, and an oxide of that metal is formed. The effect even takes place at common temperatures, and is much increased by the free access of air. In consequence of this power of corrosion, which belongs also to the solutions when mixed, as they are in sea water, all iron boilers in which sea water is used will be subjected to a much more destructive process than when fresh water is used in them, notwithstanding any degree of care that may be given to them; and if care is not given, then other serious causes of injury arise, which greatly add to the bad effects necessarily attendant on the use of sea water.

With regard to the prevention of the corrosive and injurious effects of sea water in such circumstances, I am not aware of any means that can be offered for the purpose which will embrace the whole; but from experiments made in the laboratory, a part of the evil appears to be more manageable, and capable of a remedy; and though perhaps the engineer may not find the means so available, or the advantages so important, as to make it worth while applying this remedy in the large way, yet it is important that his attention should be directed to it, that a true estimate may be formed of the circumstances connected with it.

Of the salts contained in sea water, the muriate of magnesia is that which acts most powerfully on the iron of the boiler. I boiled clean metallic iron in solutions of muriate of soda or common salt, muriate of lime, muriate of magnesia, and sulphate of magnesia, for about an hour; corrosion of the metal in all the solutions had taken place, and oxide of iron had been deposited; but the portion deposited in the muriate of magnesia was by far the greatest; and further, when the solution was filtered, it was found to hold a portion of iron even in solution, an effect which was not produced by any of the other salts.

Hence it is evident that the muriate of magnesia is a much more injurious salt than

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than any of the others existing in sea water. At the same time I am not able to say what portion of the whole injury arising to a boiler by the use of sea water in it is due to this salt. It will be seen from the table of salts given, that its quantity is only about one eighth part of that of the common salt; so that though its powers are great, they will in part be restrained by the smallness of its proportion. One thing, however, is worthy attention; namely, that the corrosive effect due to this salt may be prevented, whereas the others, as far as I know, are intractable in this respect. The muriate of magnesia is a salt composed of muriatic acid and magnesia; and it owes much of its corrosive power over the iron to the weakness of the affinity existing between its elements. This, however, enables other bodies to decompose it, producing substances that, comparatively, are inert on the iron. If for instance, lime, or potash, or soda, be added to muriate of magnesia, a muriate of lime, or of potash, or of soda, is formed, all of which are found by experiment to have less action on the metal than the magnesian salt, and magnesia is deposited. Hence, as regards the muriate of magnesia, the excess of corrosive power due to it above the other salts may be destroyed; but it is for the practical engineer to state from experience, either already in his possession, or to be had by observation, whether it may be done advantageously. The points for consideration, I presume, are, What quantity of the corrosive power compared with the whole quantity due to the sea water would be destroyed? Would any injury arise from the deposition of the magnesia that would more than counterbalance the advantage? Can the corrective agent be introduced with facility into the water? Would any inconvenience or injury, at present unknown or unforeseen, arise from the use of it?

I have ventured to put more stress on the effect of the muriate of magnesia when in solution, and on the means of correcting it, than it may perhaps seem to deserve; but I thought it my duty, when called upon for information, to give all I could; and I think the attention will not be misapplied that may be given to determine the quantity of effect due to this salt, and the possibility of correcting it.

The quantity of muriate of magnesia in a cubic foot of sea water being 3.28 oz.; the following are the equivalent quantities of the other substances concerned. It would require 1.64 oz. of dry quick lime, or 2.78 oz. of pure potash, or 4.1 oz. of dry pearl ash to decompose it; with the two first substances 1.14 oz. of magnesia would be deposited, and with the third 2.43 oz. of carbonate of magnesia.

When copper is substituted for iron in the above experiments the injurious effects are very much diminished; and it would probably be found, ultimately, that copper boilers were the most economical, and certainly the least troublesome. It must however be constantly remembered, that all mixture of copper and iron, by which I mean the use of copper and iron in contact with each other, or indeed of any two different metals, as of iron and brass, or even copper and brass, should be avoided as much as possible in those parts to which the salt water has access. When two dissimilar metals are in contact with each other, and also with sea water, a voltaic effect is produced, which occasions rapid corrosion of the most oxidable metal at the points of contact, as well as a lesser effect over its whole mass; and the action will be stronger from the circumstance of the temperature being high. Hence in the pumps or tubes connected with them and with the boiler, and in every part where the salt water passes, such combinations of dissimilar metals should as much as possible be avoided.

When a boiler charged with sea water is heated, and steam sent off from it, the following effects take place within:—the water becomes more and more concentrated, acting at the same time more powerfully on the iron. When the concentration arrives at a certain point, the sulphate of lime begins to deposit, and form crusts on the bottom and sides of the vessel. Continuing the evaporation, the water becomes so much diminished in quantity as to be unable to hold even the common salt in solution, and it begins to deposit. During the whole of this evaporation the temperature of the fluid has been rising, and it requires more heat to make it boil than it did before. Ultimately, if the operation be continued, the salts become dry in the boiler, the temperature rises, and when it attains from 270° to 300° , the muriate of magnesia is decomposed, its earth or magnesia left free, and its muriatic acid sent off in the state of gas.

Hence, it is evident, that boilers using sea water are liable to certain kinds of injury, through ignorance or carelessness, which by a knowledge of the circumstances, and attention, may be prevented. If the evaporation is carried on so far as to cause the deposition of sulphate of lime, it will tend to form crusts on the sides and bottom of the boiler; and though the addition of a fresh portion of sea water

will

will at first dissolve this, yet when the evaporation is continued it will add to the quantity of sulphate which is thrown down by the concentration. The same is the case with the common salt; upon the evaporation of a certain portion of steam from the water the salt would be deposited, and would tend, with the sulphate of lime, to form crusts at the bottom of the boiler.

One bad effect produced by this state of things is the burning of the bottom of the boiler and the flues. The heat in traversing the bottom of the boiler to reach the water, has also to pass through the crust of deposited matter, and this being of bad conducting powers obstructs its passage, and causes its accumulation in the metal itself, which of course suffers from combustion more rapidly in proportion to the elevation of temperature: at the same time, the flame and smoke, not being able to give off their heat to the already heated metal, pass on into the flues at a temperature far above what they ought to do, and burn them.

Another evil is, that less steam is raised; for the crust acting as a barrier between the fire and the water, prevents the latter from receiving that accession of heat which it ought to do; and the quantity of steam produced is proportionably less. Hence there is a waste of fuel in getting steam, or else there is a waste of steam, and at the same time there is a burning of the boilers.

A third source of injury suggests itself, which, though I am not aware it has been observed in practice, well deserves pointing out, that if any effect should arise from it, it may be distinguished and guarded against. I refer to the decomposition of the muriate of magnesia by a heat approaching 300° F. This effect can never take place whilst the salt remains in solution, and it is the most soluble of any of the salts in sea water. But whenever any portion of the common salt is rendered dry, and caked, it is then possible that muriate of magnesia should be decomposed, and its muriatic acid liberated in a free state. Thus, if from the concentration of the sea water a crust of common salt and sulphate of lime had formed on the bottom of the boiler, it would act as before mentioned, by preventing the transmission of the heat through it, which would consequently accumulate on the lower side, and any portion of muriate of magnesia contained in the crust would then be decomposed; its free acid partly acting on and combining with the iron at the bottom, and partly passing into the water, and from thence wherever the water or steam passed. Again; I believe there are instances known where the water has been suffered to sink below the level of the upper surface of the flue, or furnace, which sometimes passes through the boiler; in such case, any portion of muriate of magnesia left on the top of this flue would be heated, and if sufficiently so, would be decomposed as before.

From the possibility, therefore, that this highly injurious effect may take place, I think it very desirable, where engineers have cause to suspect carelessness in the attendance of boilers using sea water, that they should look for the effects that are to be expected. These, beside great internal corrosion of the bottom, may even extend to the steam passages, inasmuch as the acid liberated is volatile; and if the water in the boiler is found to hold iron, not in a state of suspension only, but in actual solution, it would be well to compare its quantity with that which sea water by mere boiling may be made to take up.

The evident remedy for the injuries that may arise from the concentration of the sea water below the point at which it deposits salt, and the only one that suggests itself to me, is the removal of the water in the boiler before it acquires this undue degree of concentration. In doing this, there can be no difficulty; and I should conceive it may be done in such a way as to occasion very little loss of heat by the water thrown out. The practicability, however, of such a plan, may be better judged of after a consideration of the various points of deposition and temperature, and the quantities of water that may be abstracted as steam before their occurrence. Sea water in a close vessel, but at common atmospheric pressure, boils at 214° F. very nearly. Suppose 1,000 parts of such sea water, and the evaporation continued until the sulphate of lime began to deposit; this took place in my experiments, when 701 parts of steam had been driven off, and when consequently 299 parts of salt and water remained. The temperature of the water in ebullition was then 217° F. As the evaporation went on, more and more sulphate of lime was deposited, and the thermometer rose until the temperature was 228° F. when common salt began to deposit, and when 898.3 parts of steam had been abstracted. Still continuing the ebullition, salt and sulphate of lime were deposited in considerable quantities, and the temperature still rose, because of the concentration of the muriate of

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of magnesia in the solution. The muriate of magnesia was not however deposited until the whole was dry, being retained in solution till the last.

Hence it follows, that taking 1000 parts by weight of sea water, 701 parts may be converted into steam before any deposit at all takes place in it; and that 868.3 parts of steam may be obtained before any common salt will be deposited. It also follows, that sea water, boiling at common pressure at less than 217° F. is not depositing any thing; and that boiling at temperatures below 228° F. it is not depositing common salt.

It is now easy to ascertain the propriety of changing the water in a boiler. If the water left in it at the end of the voyage is less than three tenths of the whole quantity introduced, it will deposit sulphate of lime; and if it is less than one tenth, it will deposit common salt; and the more the diminution below these quantities, the greater the depositions. It is also evident, that with a small boiler intended to supply the same quantity of steam as a larger one, the necessity of changing the water will be greater and more frequent.

I am not aware of all the circumstances that influence the quantity of water necessary to be added to that with which the engine is first set to work; but I should presume both they and the quantity are variable. At sea, where every portion of water introduced into the boiler from the sea is the means of introducing a fresh portion of salt, I should think it would always be an object to supply the boiler as much as possible from the condensed water of the steam that has passed through the engine; and the more perfectly this is done the less the necessity for any precautions respecting the deposition of salt in the boiler. As, however, the evidence proves, that even in short voyages, lasting but a few hours, the water in the boiler has been so concentrated as to deposit abundance of salt, it is evident that there is a necessity for changing it, by allowing the escape of the concentrated water, and introducing fresh portions.

The means of doing this are in the hands of every engineer, and I should think might be so applied as to occasion very little loss of heat. The indications, when it may be necessary, may be founded both on the temperature at which the water is boiling, and on its specific gravity. With regard to the latter, I think the best instrument the man could have would be the hydrometer, with one, or at most two marks upon it, the one to indicate the density of the water when it begins to deposit common salt, and the other, the density perhaps when it begins to deposit sulphate of lime. Regard must of course be had to the temperature, but that is a point easily arranged.

The indications by temperature would be obtained by inserting a thermometer into the boiler; certain precautions, however, would be required in its application. In the first place, it is essential that the thermometer dip into the water, for the atmosphere of steam which is above the surface of boiling sea water, or of, I believe, all saline solutions, is not, at any pressure, at the same temperature as the water itself, but always lower, and the more so as the water is more concentrated. In the second place, the temperature both of the water and steam will vary with variations of the pressure in the boiler; but this, when ascertained by the steam gauge, easily gives the correction, which, added to the temperatures I have given, will give the temperatures for the various points, in the circumstances of the altered pressure.

When the consumption of water by a steam engine, or rather, I would say, its waste, for I mean the portion that is lost by the steam-vent, and in other ways, is known, it is easy to ascertain whether it would be advantageous to go to sea at first with fresh water in the boiler. If this precaution sufficiently balances the concentration caused by the loss of steam, it is effectual; if not, it only incurs or retards it. The propriety of selecting such waters as contain no earthy matter, as carbonate or sulphate of lime, or any substance which may deposit in and clog the boiler, is evident from the effects produced in many of the steam-engine boilers in Cornwall.

Proust has lately demonstrated the existence of mercury in sea water. The quantity of this substance contained in it is probably far too small to cause any injury to steam engines at sea. At the same time, it is matter of interesting, and perhaps useful inquiry, to ascertain whether it may not have an effect. The high temperature of parts of the engine would favour its action, and perhaps make the existence of that substance sensible in those situations where till now it has escaped observation.

Capt.—The proper selection and state of the coals used on board steam vessels, especially when one very great object is to secure a regular and short passage, whatever

whatever the state of the weather may be, is very important. I am not, however, sufficiently acquainted with the varieties of coal raised in this country to state the particular qualities which distinguish them, or to point out the best for this particular purpose. As however it is not practicable to have access to any coal at pleasure, all that can be done is to ascertain the qualities of those within reach, and choose the best.

All coal containing pyrites should be rejected, or at least the purest kind selected. Mention has been made before the Committee of the spontaneous inflammation of coal on board a steam vessel. This is an effect which, I believe, not unfrequently takes place at the pit mouth, and when produced, it is due to the pyrites or sulphuret of iron the coal contains. When large masses of coal containing this substance are exposed to air and moisture, those agents sometimes act on the pyrites, causing the oxydation of the iron in them, and liberating sulphur and combustible aerial products; and the heat produced by this action accumulating in the mass, sometimes rises so high as to fire the sulphur and sulphuretted gases, and these inflame the coal, so that the combustion of the mass is produced without the approximation of any ignited body.

The coals in steam vessels are generally, I believe, put into boxes at the sides of the place where the engine stands, and I do not think that with moderate caution they can fire there; *i. e.* provided the communication between them and the furnaces be prevented; for their masses are comparatively so small, and they remain for so very short a time together undisturbed, that it is not probable the mere action of air and moisture on the pyrites they contain should inflame them. It is true, the elevation of temperature in the place in which they are stored, caused by the vicinity of the furnaces, will be favourable to such an effect; but I do not think its influence would be dangerous, except with very bad coals indeed. It would however be easy at all times to know the state of the coals, by having one, two, or three iron pipes going across the boxes in which they are put; any tendency in the coals to heat would heat the pipes also, and might be detected by a thermometer being placed in them.

The pyrites contained in coal have probably a more injurious effect in steam vessels, by the action they give rise to on the bottom of the boiler, and on the iron of the furnace and flues. Whatever part the sulphur or sulphureous vapours come in contact with, it attacks, and causes its destruction; hence a rapid and premature decay. They tend also to increase the quantity of slag in the furnace, and thus embarrass the grate; and this latter effect is increased by the mixture of dirt with the coals. I am not sufficiently acquainted with large furnace fires to know the most advantageous mode of managing them, but there are evidently some curious and apparently conflicting circumstances, which require attention. Were coal a pure combustible matter, there would be no difficulty in saying, that, generally, the whole should be burnt, and made to produce the highest heat possible; but being a mixture of pure combustible matter with earthy substances, oxide of iron, and generally pyrites, in greater or smaller quantity, it becomes a point for consideration whether it shall be made to produce the highest possible heat in the furnace, or a moderated one. With the highest heat the residue forms a glassy slag, which rests on the grate, and chokes the apertures; with a moderated heat the slag is not formed, but the ashes that fall through the grate contain much combustible matter. In practice, I believe, it is found advantageous to preserve a stratum of clinkers, or broken slag, on the bars of the grate, which preserves them cool, and diminishes, to a certain extent, their combustion and decay; and I have seen furnaces in which, by this means, large and powerful fires had been going on for years over very thin bars, without injuring them. Where however the coals are liable to vary in quality, the practice must vary also. But this much is certain, that the clinkers or slag will be in proportion to the earthy and ferruginous matter in the coal, and to the heat to which it is exposed; and also that the presence of pyrites considerably facilitates and hastens the formation of slag; so that it will be produced at a lower temperature than if no pyrites were in the coal: and consequently, it results, that whenever the best and most certain effect is required in a steam vessel, coals should not be used indiscriminately, but a selection made from among such as can be obtained, those being preferred which contain least pyrites and earthy matter.

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Mr. Joshua Field, again called in; and Examined.

Mr. J. Field.

(1 *Just.*)

HAS any improvement been adapted with respect to the chimnies of steam vessels?—I believe nothing further than the making them elliptical, so as to oppose less resistance to a head wind.

Have chimnies of this description been put up on board any vessels?—There are two at present working with elliptical chimnies; the *Victory*, to Margate, and the *Rob Roy*, between Dover and Calais.

Are they found to answer?—They consider that the vessels go head to wind better than without them.

What is the common diameter of a circular chimney for two forty-horse engines?—About two feet six.

What is the power of the *Victory*?—Two twenties.

What is the greatest breadth of her elliptical chimney?—That I cannot exactly state, but the dimensions are determined by giving the same area.

Mr. Bryan Donkin, again called in; and Examined.

Mr. B. Donkin.

REFERRING to your evidence of the 3d of May, concerning the inspection of steam vessels, in which you say, that you think the vessels ought to be inspected once in three, or at least once in six months, what description of inspection would you recommend, supposing that the number of vessels employed were four, and that two of them were to go to sea every day throughout the year, to perform a sea voyage of fifty-four miles?—Considering the property necessarily involved in such an establishment, and the situation at which the business would be carried on, at a distance from any professional engineers, I should recommend a resident engineer, who should examine the vessels daily.

Is it not the practice, where a great extent of machinery is in use, to have this sort of inspection in other concerns?—In a variety of concerns it is, such as canals and docks, and large manufacturing concerns, they have men conversant with the particular machinery employed.